

Volume 1 of 2

**SOIL VAPOR EXTRACTION (SVE)
FINAL REMEDY CONSENT DECREE
FINAL EXTRACTION AND TREATMENT
SYSTEM DESIGN PHOENIX-GOODYEAR
AIRPORT (SOUTH) SUPERFUND SITE
GOODYEAR, ARIZONA**

Submitted to:

**The Goodyear Tire and Rubber Company
Akron, Ohio**

**September 10, 1992
(Revised November 25, 1992)**



**Metcalf & Eddy, Inc.
816 State Street, Suite 500
Santa Barbara, CA 93101**

REPORT

Volume 1 of 2

**SOIL VAPOR EXTRACTION (SVE) FINAL REMEDY
CONSENT DECREE FINAL EXTRACTION AND TREATMENT
SYSTEM DESIGN PHOENIX-GOODYEAR AIRPORT (SOUTH)
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**Metcalf & Eddy, Inc.
816 State Street, Suite 500
Santa Barbara, CA 93101**

November 25, 1992

Mr. Craig Cooper
U.S. EPA H-7-2
75 Hawthorne Street
San Francisco, CA 94105

**Subject: SVE Final Design Document-Revision
Phoenix-Goodyear Airport Site
Goodyear, Arizona**

Dear Mr. Cooper:

Attached is the Revised SVE Final Design Document for the Phoenix-Goodyear Airport site in Goodyear, Arizona. This report is submitted on behalf of the Goodyear Tire and Rubber Company in accordance with the Consent Decree (Section VIII D-8). This document fulfills the tasks in the Consent Decree as well as fulfilling the tasks in the SVE Design Memorandum (May 1992).

Because the U.S. EPA does not consider a difference between the 90% and Final Design, the Consent Decree schedule for SVE remedy has been modified (letter from Craig Cooper, U.S. EPA, to Ed Waltz of Goodyear Tire and Rubber Company dated June 3, 1992). The SVE 90% Design Document is considered the Final Design document and therefore moves up the schedule on subsequent Consent Decree deliverables. Some of the references to the 90% SVE Design have been maintained in the report to conform with the language contained in the 1990 Consent Decree.

This SVE Final Design Document includes changes that address the November 2, 1992 U.S. EPA comments to the Draft SVE Final Design Document.

The primary difference between this and the Draft SVE Final Design Document is that a formal design and schedule has presented for soil vapor extraction remediation of Polygon 79.

This change is a result of reconfiguring the VLEACH and Mixing Cell input data and adjusting the Mixing Cell simulation interval to the VLEACH output. These changes caused two of the four polygons investigated in May of 1992 to result in Subunit A groundwater degradation above 5 $\mu\text{g/L}$, the site clean up level. These polygons are 79 and 92.

As a result, the SVE operable unit was designed for Polygon 79 based on it have the larger impact to Subunit A groundwater than Polygon 92.

GOODYEAR/SVE92.LET

Since no further investigation is required to determine if any polygons require SVE remedy, the dual critical path schedule presented in Draft SVE Final Design Document is no longer necessary.

The schedule presented has one critical path with two stipulated Consent Decree deadlines. The first deadline is the commencement of SVE system construction within 60 days following U.S. EPA approval of the SVE Final Design (Section VII, D-12). The second deadline is the commencement of SVE Operable Unit Startup within 210 days of U.S. EPA approval of the SVE Final Design. (Section VII, D-13).

Appendices A and B in this document remain in draft form for the incorporation of SVE operable unit operation and maintenance information provided by the SVE equipment vendors and generated during SVE system startup. A final draft will be prepared and submitted to U.S. EPA prior to system startup.

A Final Operation and Maintenance Manual combining Appendices A and B will be submitted under separate cover to U.S. EPA within the Consent Decree stipulated time of 60 days following startup (Section VII, Subsection D-14).

Lastly, this SVE Final Design Document includes the results of VLEACH and Mixing Cell screening of the top 32 site polygons. The results indicate that a total of seventeen (17) polygons result in Subunit A groundwater degradation above 5 $\mu\text{g/L}$. Of the seventeen polygons, two require SVE remedy and include polygons 79 and 92.

The remaining fifteen (15) polygons are scheduled for further Phase I/II investigation and/or VLEACH and Mixing Cell screening.

The SVE Final Design Document details the investigation of nine (9) of the fifteen polygons with subsequent VLEACH and Mixing Cell screening of all fifteen polygons.

The results of the investigation and polygon screening will be prioritized for SVE remedy, investigation, or to be dropped from further consideration whichever is required.

Although there is no stipulated time table for the investigation of the polygons, Goodyear will conduct the investigation in a timely manner that maximizes field effort.

Mr. Craig Cooper
November 25, 1992

-3-

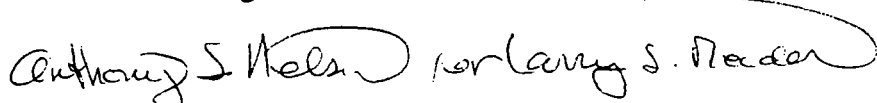
The technical discussions we have had in the past following report submittal have kept this project on schedule. If you have any questions regarding this report, please feel free to call Scott Zachary, Todd Struttman or Ed Waltz.

Sincerely,

METCALF & EDDY, INC.



Scott P. Zachary
SVE Task Manager



Larry S. Reider, P.E.
Senior Project Engineer

SPZ/ef

Attachments:

- 1 - Response to U.S. EPA comments
- 2 - SVE Final Design Document (2 vols)

cc: E. Waltz, Goodyear Tire and Rubber Company
M. Bolitho, Arizona Department of Water Resources
B. James, Arizona Department of Environmental Quality
L. Smith, URS Consultants
R. Bartholemew, Bartholemew Engineering
T. Struttman, Sharp and Associates



UNITED STATES

OPTIONAL FORM NO. 10 (7-80)

FAX TRANSMITTAL

3 of pages 8

To: <i>Scott Zachary</i>	From: <i>CRAIG COOPER</i>
Dept./Agency: <i>Metcalfe & Eddy</i>	Phone: <i>415 744-2370</i>
Fax: <i>619 233-7861</i>	Fax: <i>415 744-1917</i>
NSN 7540-01-017-7369	GENERAL SERVICES ADMINISTRATION

VIA OVERNIGHT EXPRESS MAIL

November 2, 1992

Mr. Ed Waltz
Goodyear Tire and Rubber Company
1144 East Market Street
Akron, Ohio 44316

RE: Phoenix-Goodyear Airport Superfund Site (south)
Final Remedy Consent Decree; Civil Action 88-1443 PHX RHC
Final Comments on SVE Final Design

Dear Mr. Waltz:

EPA has completed its review of the document entitled Soil Vapor Extraction (SVE) Final Remedy Consent Decree Final Extraction and Treatment System Design Phoenix-Goodyear Airport (south) Superfund Site; Goodyear, Arizona dated September 10, 1992, hereafter referred to as the "SVE Final Design". This document was submitted to EPA by Metcalf & Eddy Engineers Inc. on behalf of the Goodyear Tire and Rubber Company in accordance with the above-referenced Consent Decree. EPA hereby disapproves the SVE Final Design with comment provided in Enclosure One.

In accordance with Section VIII.B.2. of the above-referenced Consent Decree, upon receipt of this letter Goodyear shall have fifteen (15) working days to address each EPA comment in Enclosure One and resubmit a revised SVE Final Design. Please be aware that in accordance with Section VIII.B.5., if EPA disapproves the revised SVE Final Design, Goodyear may be found to be in non-compliance with the Consent Decree.

Please call me at (415) 744-2370 with any questions regarding this letter and its enclosure. EPA will continue to be available for conference calls as we had on October 28 when EPA outlined several of its major findings regarding the SVE Final Design.

Sincerely,

Craig Cooper
Remedial Project Manager

Enclosure

cc: Todd Struttman, Sharp & Associates
Scott Zachary, Metcalf & Eddy
Larry Smith, URS Consultants; Byron James, ADEQ

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ENCLOSURE ONE

The following comments are provided by EPA in response to review of "Soil Vapor Extraction (SVE) Final Remedy Consent Decree Final Extraction and Treatment System Design Phoenix-Goodyear Airport (South) Superfund Site Goodyear, Arizona", September 10, 1992, submitted by Goodyear Tire & Rubber Company.

General Comments

1. Mixing cell runs for all polygons are incorrect. In these runs, mixing cell program underestimates the groundwater concentration by approximately one order. This must have resulted due to the following error in the program: flux of water entering mixing cell is calculated as volume per day, but the residual mass in the mixing cell is calculated for (1/10)th of a day. To correct this problem, residual mass calculation should be performed for an increment of one day instead of (1/10)th of a day.
2. The value used for volumetric water content ($\theta_v = 15.6\%$) is incorrect. As shown in Table 2-4 and Appendix J, the reported moisture content value (15.6%) is based on the ASTM D2216, which indicates that the moisture content is mass based (moisture content = mass of moisture/ mass of dry soil), and not volume based as interpreted in page 40 of the report.

The following equation can be used to convert mass based moisture content (m) to volumetric moisture content (or water filled porosity) θ_v :

$$\theta_v = \frac{\rho_b}{\rho_w} m \quad (I)$$

where,

- θ_v = Water filled porosity of soil (non-dimensional)
- ρ_b = Dry bulk density of soil (g/cm^3)
- ρ_w = Density of water ($= 1.0 g/cm^3$)
- m = Moisture content of soil (mass of moisture/mass of dry soil, non-dimensional)

Using $m = 0.1554$ and $\rho_b = 1.64 \text{ g/cm}^3$ in Eq.(I) gives $\theta_v = 0.2549$. Thus, total porosity = 0.381, water filled porosity = 0.2549 and air filled porosity = 0.1261 are the values that should be used in VLEACH.

3. The value of k_{pc} is affected by the value of θ_v . Using the correct value for water filled porosity, calculate the value of k_{pc} (=0.599 l/kg). Use this corrected value to revise vertical soil concentration used in VLEACH for all polygons.
4. Input file for Polygon 92 (Appendix I) shows a value for $q = 0.020014 \text{ ft/year}$ is used in VLEACH run. As used in the past, $q = 0.02667 \text{ ft/year}$ should be used for this polygon.

Specific Comments

1. Page vii of vii. Paragraph 2.

The sentence before the last in this paragraph "..... above the U.S.EPA maximum contaminant level (MCL) for trichlorethylene (TCE)." should read as "..... above the groundwater clean-up levels for the VOCs presented in Table 2-5 of September 1989 Record of Decision for the Phoenix-Goodyear Airport (PGA) Site."

2. Page viii of vii.

(a) Change the page number (do the same for the subsequent pages in this chapter)..

- (b) Paragraph 2.

The year of the reference (1986/1987 RI/FS) for Phoenix-Goodyear Airport RI/FS is not correct since RI/FS work at PGA continued until September 1989. This incorrect reference date has been noticed throughout the report.

3. Page 1, Paragraph 1.

(a) Reference of Figure 2-1 is inappropriate in this paragraph.

(b) In the third sentence of this paragraph remove "Subparagraph C.6 and C.7 of" from its current location and insert it after "...the requirements of...".

4. Page 3

Twice on this page and throughout the report the statement "....VOCs that will result in Subunit A

groundwater concentrations in excess of 5ug/l..." is used. This is not the way the Record of Decision or Consent Decree requirements are stated. Please explain.

5. Page 5, Paragraph 1

EPA firmly disagrees with the conclusions made in this paragraph. EPA's analysis of the data for polygons 92 and 79 indicates that SVE Operable Unit remedy is indeed required there. We have not completed our analysis for polygons 116 and 117. As was stated during our October 28, 1992 conference call, Goodyear shall correct their data analysis procedures in accordance with EPA's comments herein and then re-run VLEACH and mixing cell analyses for polygons 92, 79, 116, and 117 as soon as possible. Goodyear shall then immediately inform EPA by telephone with the results of these analyses. EPA will then verbally pre-approve: (a) Goodyear's recommended first polygon to be remediated; and if offered by Goodyear, (b) Goodyear's recommended next four polygons to be investigated. This EPA "pre-approval" is required for communication and organization purposes only and does not waive or impact in any way EPA rights to comment and/or approve/disapprove the Revised SVE Final Design Package. Goodyear will then proceed with the proper revisions to the SVE Final Design and resubmit this document in accordance with the timeframes allowed by the Consent Decree. If the Revised SVE Final Design is disapproved by EPA, Goodyear may be found in non-compliance with the Consent Decree.

6. Page 6, Bottom Paragraph

Remove "TCE" from the first sentence.

7. Page 33, Paragraph 1, and Page 35, Paragraph 2.

Explain the meaning of "Vertical profiling of soil head space concentration with depth....".

8. Page 38, Paragraph 2.

As indicated in the General Comment No. 2, use the correct value for volumetric water content ($\theta_v = 0.2549$).

9. Page 52, Paragraph 4.

The discussion related to the thickness of vadose zone is irrelevant. The mass of VOC in the vadose zone is calculated using measured concentration distribution in the 60 feet thick vadose zone (see Table 2-12). This means that the mass is not calculated based on a thickness of 62 feet and then redistributed within 60

feet as claimed in this paragraph. Remove this discussion from this paragraph.

10. Page 56, Table 2-8.

- (a) Value of F_{oc} should be equal to 0.0744.
- (b) Use the correct value for θ_v (=0.2549).
- (c) Include the unit of k_{oc} (ml/g).
- (d) Using the correct value for water filled porosity, calculate the value of k_{gc} (=0.599 l/kg).

11. Page 64, Table 2-10.

Revise this table using the correct k_{gc} (=0.599 l/kg) value.

12. Page 66, Equation (1).

Equation (1) should be corrected as shown below:

$$C_T = \left[\left\{ \frac{(k_d \rho_b + \theta_v)}{k_b} + (\theta_T - \theta_v) \right\} \frac{1}{\rho_b} \right] C_s \quad (1)$$

13. Page 70, Table 2-11a.

Soil concentration for VS-VP92-28 is 368 (not 386 as shown in this table).

14. Page 70, Table 2-12a.

Include the concentration value for depth = 51 feet.

15. Page 76.

Define C_r , Z , and C_s in Equations 9 and 10.

16. Page 77, Paragraph 3.

The first sentence "... corresponds to first 0.6 foot intervals, ..." should be "... corresponds to first 0-6 feet interval,....".

17. Page 78, Table 2-14a.

Area of polygon 96 is 83000 sq.ft, but the calculation is done using a value of 63000 sq.ft.

18. Page 80, Table 2-8

Are conditions "B" and "C" mislabeled in relation to the

text?

19. Page 83, Table 2-15.

Values for the parameters do not match.

20. Page 93, Table 2-16.

Value for Hydraulic Conductivity (gpd/sq.ft) should be 344.83.

21. Section 3.4; Pages 115-121.

(a) State clearly where carbon bed regeneration will occur. Regeneration facilities at the Subunit A Groundwater Treatment Plant may be used only if EPA approves the Revised Subunit A O&M Manual and this manual includes procedures for regeneration of the SVE carbon beds. As stated to Goodyear before, based on the current layout of the air emission controls constructed to date at Subunit A Groundwater Treatment Plant, EPA is concerned about potential, unacceptable VOC releases and/or potential, unacceptable Subunit A extraction well downtime during regeneration activities. Therefore, EPA wishes to review the Revised Subunit A O&M Manual as soon as possible and no later than 60 days after start-up of the air emission controls at the Subunit A Groundwater Treatment Plant. Since use of the Subunit A regeneration facilities may not be acceptable to EPA for purposes of the SVE Remedy, Goodyear shall describe a contingency regeneration facility in the SVE Final Design package.

(b) Include a calculation of carbon bed usage rates and replacement intervals. Since the reliability of the "between bed" vapor analyzer has not been established, an air monitoring program for potential VOC atmospheric emissions during start-up and routine operations is also required. This air monitoring program shall be included in the Monitoring Plan to be included in the SVE O&M Plan (see comment 25 below).

22. Page 120, Paragraph 5

How is it known that the sump water will be clean? This should be verified before the water is discharged onto the ground.

23. Page 128, Paragraph 3

What types of warning signs will be posted on the security fence?

24. Section Four and Five; Pages 129-147.

Modify Polygons to be investigated next based on Goodyear re-running of the VLEACH and Mixing Cell Models (see General Comment 1 above). Selected polygon(s) to be investigated shall be verbally pre-approved by EPA (see comment 5). Incorporate procedures outlined in Scott Zachary's October 23 letter except that actual depth of the caliche layer in each Phase I boring shall be used to determine final soil gas sampling depths.

25. Appendix A; SVE Unit Operation & Maintenance (O&M) Manual.

Appendix A is obviously in a preliminary draft condition. However, significant revision to Appendix A is not required in the Revised SVE Final Design package if Goodyear agrees to the following:

(a) A draft SVE O&M Plan is finalize by Goodyear and submitted for EPA review and comment prior to SVE system testing and start-up (this already stated on page A-2);

(b) In Section VII.D.14 of the Consent Decree, word "may" is changed to "shall" on line 11, page 14 of the Consent Decree. If changed, Goodyear shall submit a Final SVE O&M Plan upon 60 days of the SVE start-up day. This Final SVE O&M Plan shall be subject to EPA review, comment, and approval.;

(c) Goodyear continues to address and incorporate EPA comments on the SVE O&M Plan in this letter, on the Draft (pre-start-up) O&M Plan and on the Final O&M Plan.

26. Appendix A; SVE O&M Plan

An SVE Monitoring Plan shall be included in the SVE O&M Plan. Figure B1 is an inadequate Monitoring Plan. The SVE Monitoring Plan shall consist of a Field Sampling Plan and a Quality Assurance Project Plan (QAPjP) in accordance with EPA Region 9 guidance. Since a single document SVE O&M Plan is preferable, combine Appendices A and B in future drafts.

27. Appendix B and Appendix F

EPA has some significant concerns regarding these Appendices. We should have a conference call on these two Appendices so that we can discuss EPA's comments in detail. As to Appendix F, the Maricopa County air permit is not needed. Goodyear may pursue this permit if it wishes to do so. However, no extensions to the Consent Decree schedule will be allowed for any related permitting issues. In Appendix B, it appears that Goodyear believes that SVE extraction wells for a given polygon are to be installed in a manner that allows for significant delays before all wells are in place. In fact, Appendix B appears to be an SVE pilot program which is not warranted since this was already accomplished at this site in 1988. As I have explained before, the term "sub-area" in the Consent Decree means

"polygon" during remedial design and remedial action. However, during the operation and maintenance mode for application of Appendix B of the Consent Decree, "sub-area" means the radius of influence from a single extraction well. Therefore, this means that for each polygon that requires an SVE remedy, a comprehensive SVE system shall be designed and constructed to fully address that entire polygon. An SVE remedy shall not be slowly phased into a polygon. When an SVE remedy in a polygon commences routine operation O&M mode, Appendix B of the Consent Decree can be applied to individual wells to optimize appropriate well pulsing and contaminant rebound monitoring.

27. Appendix K - Plans and Specifications

Replace information on polygons 21A-26A with the final full and complete plans and specifications for either polygons 92, 79, 116, or 117, which ever exceeds the soil clean-up standard the most. As stated before, EPA believes that both Polygons 92 or 79 need to be remediated. Prior to Goodyear's resubmission of SVE Final Design package, EPA will verbally pre-approve which polygon's plans and specifications should be included in Appendix K (see comment 5 above). Please be sure that the specifications along with a construction quality assurance plan are included in the revised SVE Final Design. Design specifications were omitted from the current SVE Final Design.

28. Appendix G, Page G-25

The emergency phone number list should be posted in a location where it could be easily located during an emergency.

PGA - SVE FINAL DESIGN
RESPONSE TO U.S. EPA COMMENTS
November 25, 1992

1.0 GENERAL COMMENTS

Comment 1 Response

Goodyear concurs with U.S. EPA findings on the Mixing Cell modeling. M&E has implemented a change in the Mixing Cell algorithm to facilitate consistent data handling. See Appendix M for the revised Mixing Cell algorithm. The change to the algorithm standardizes the calculation between the mass input time step and the hydraulic conductivity time step. The change to the model was confined by teleconference with U.S. EPA and its consultant on November 2, 1992.

Comment 2 Response

Goodyear concurs with U.S. EPA findings with respect to the vadose zone volumetric water content. M&E has converted the laboratory water content (wt%) to a volumetric water content through the use of equation (I) in the U.S. EPA comments. The resultant volumetric water content was calculated to be 0.2549 which was rounded to 0.255 for VLEACH input. See Table 2-4.

Comment 3 Response

Based on the changes listed in Comment 2, Goodyear concurs with U.S. EPA and the value, K_{gt} has been recalculated. The new value of K_{gt} is 0.599 L/Kg. See Table 2-8.

Comment 4 Response

Goodyear concurs with the U.S. EPA stated recharge value of 0.02667 ft/yr for Polygon 92. This change has been made in Appendix I, the VLEACH input file. The current execution of VLEACH for Polygon 92 includes this change.

2.0 SPECIFIC COMMENTS

Comment 1 Response

The requested change is noted and has been changed in the document. See Executive Summary.

Comment 2 Response

- a. Page numbering has been changed to reflect current total and consecutive pages.
- b. M&E has changed all references in the document from 1986/1987 RI/FS to 1989 RI/FS.

Comment 3 Response

- a. Comment is noted and figure reference 2-1 has been removed from text.
- b. Comment is noted and the paragraph portion "Subparagraph C.6 and C.7" has been appropriately moved.

Comment 4 Response

The 1990 Consent Decree states that the soil vapor extraction unit will be installed in areas of the site "where VOC residues pose a threat to groundwater quality in Subunit A as provided in Subparagraph C.6 and C.7.

Subparagraph C.6 establishes that VOC residues are based on soil gas concentrations. Additionally, Subparagraph C.7, subsection b.i states that SVE operation shall continue until the requirements of Appendix B of the Consent Decree have been satisfied.

Appendix B of the Consent Decree is the Soil Vapor Extraction Flow Chart illustrating sub-area operation. Once a sub-area enters into SVE remedy, operation will continue until the VOC residues, as determined by soil gas, fall below the allowable residual mass (ARM) for the sub-area. The allowable residual mass of a given sub-area is the soil vapor concentration, converted to total soil concentration, when inserted into the VLEACH and Mixing Cell Models, result in Subunit A ground water degradation. Based on the site cleanup level for TCE, groundwater degradation is defined as a concentration of halocarbons equal to or in excess of 5 µg/L. Based on this rationale, the wording was developed for use in the SVE Design Memorandum and SVE Final Design Document.

Comment 5 Response

Goodyear concurs with U.S. EPA comments regarding polygons requiring SVE remediation. This conclusion is based on the results of the revised VLEACH and Mixing Cell modeling that incorporates the changes noted in General Comments 1-4 above.

Based on the new VLEACH and Mixing Cell polygon screening, two polygons have been prioritized for SVE operable unit remedy, and fifteen polygons have been prioritized for additional vadose zone Phase I/II investigation and/or VLEACH and Mixing Cell screening. Polygon 92 also requires SVE remedy. This SVE Final Design Document presents the 90% Complete Conceptual Design for the SVE operable unit for Polygon 79.

Following the investigation of 9 of the polygons, VLEACH and Mixing Cell will be used to prioritize all 15 of them for SVE remedy, further investigation, or to be dropped from further SVE consideration. See sections 2-5 for detailed explanation.

Comment 6 Response

Comment noted and change has been made to document.

Comment 7 Response

Following Phase II boring activities, M&E analyzed soil headspace VOC concentrations. The soil headspace analytical results were used solely to adjust vertical positioning of soil vapor monitoring well screen intervals to ensure that the screen intersected the highest VOC concentrations within the screened zones.

Soil headspace analyses were not used for development of vertical soil vapor profiles for VLEACH modeling.

Comment 8 Response

The recalculated volumetric water content value of 0.255 has been corrected on p. 38, Paragraph 2, as well as throughout the rest of the document.

Comment 9 Response

U.S. EPA comment noted and text has been removed from the document.

Comment 10 Response

Table 2-8 of this document reflects the recalculated values for VLEACH and Mixing Cell modeling.

Comment 11 Response

As stated in General Comment 3 above, the recalculated K_{gt} value of 0.599 L/Kg has been input throughout the document.

Comment 12 Response

The U.S. EPA comment is noted and Equation #1 has been corrected to reflect the U.S. EPA-preferred format.

Comment 13 Response

The U.S. EPA comment is noted, however, all of the previous values for Table 2-11a have been changed to reflect the recalculated K_{gt} value of 0.599 L/Kg.

Comment 14 Response

The U.S. EPA reference to Table 2-12a is incorrect, the correct Table reference is Table 2-11b. U.S. EPA comment is noted and the 51-foot concentration entry has been incorporated into Table 2-11b.

Comment 15 Response

The equation variables C_z , Z , and C_s have been defined following Equations #9 and #10.

Comment 16 Response

The U.S. EPA comment has been noted and the interval has been corrected to read "0-6 foot intervals."

Comment 17 Response

The area for Polygon 96 is 83,000 ft² and the document has been revised to reflect this area. The change has also been made in Appendix I for VLEACH model input.

Comment 18 Response

The discussion on Page 80 identifying three vertical distribution profiles labelled as "A", "B", and "C" has been removed from the document. Rather than weighting vertical soil concentrations as "top-loaded," or "bottom loaded," M&E has utilized existing 1989 RI/FS data in-kind for each polygon. The result of this approach was to minimize the carryover errors associated with numerically redistributing total soil concentrations from a historic 62.5-foot thick Subunit A vadose zone to a 60.0-foot thick vadose zone (e.g., maximum error is less than 2% using this approach which is negligible with respect to VLEACH modelling).

Comment 19 Response

Comment noted and changes to values of parameters listed in Table 2-15 currently match.

Comment 20 Response

U.S. EPA comment is noted and the hydraulic conductivity of 344.83 gpd/ft₂ has been inserted in Table 2-16.

Comment 21 Response

- a. It is not known at this time exactly where SVE carbon bed regeneration will occur. The SVE system design stipulates that all carbon regeneration will be carried out by a licensed carbon regeneration contractor and/or at a licensed regeneration facility.

No regeneration activities on site will involve the Subunit A groundwater treatment system.

Once Goodyear has selected a vendor for carbon supply, both the primary and contingency carbon regeneration facility will be specified. Goodyear will include this information in the Final SVE O&M manual to be submitted to U.S. EPA under separate cover.

- b. Carbon bed utilization calculations have been included in Section 3 of this document. Additionally, the reliability of the solvent vapor monitor between the carbon beds will be established during system startup. Goodyear will submit a formal air emissions monitoring program that will be included in the SVE operable unit O&M plan.

Comment 22 Response

Page 112, Paragraph 3, and Appendix N specifies periodic stack sump sampling and field GC headspace analysis of collected liquids. Only if GC results indicate the presence of no detected indicator VOCs (TCE, PCE, 1,1-DCE, and 1,1,1-TCA) in stack sump liquids will discharge on the ground surface be initiated. If any indicator VOCs are detected in the stack sump liquids, the liquids will be drummed and transported to the Subunit A air stripping system for treatment.

Comment 23 Response

Warning signs that will be placed around the SVE treatment unit will include:

- Rules for access/entry
- Safety equipment required
- Non-smoking area
- Hazardous or flammable materials
- Hot surfaces
- Machinery/moving parts
- Noise levels - hearing protection required
- High voltage - electrical danger

Section 3 includes these additions.

Comment 24 Response

The VLEACH and Mixing Cell model has been re-executed on the top 32 polygons using the recalculated values discussed in General Comments 1-4 above.

The results of the new polygon screening have been prioritized to remediate Polygon 79 and to investigate nine additional polygons. These polygons include: 21A-26A, 111, 113, 13A, 96, 65, 38, 36, and 15A.

The Phase I of this investigation has been modified to collect shallow soil vapor samples both above and below the site caliche layer. See Section 2.

Comment 25 Response

Goodyear agrees with U.S. EPA that Appendices A and B are in draft form. As information from the SVE equipment vendors, as well as from the SVE operable unit startup become available, the information will be incorporated.

The two appendices will be combined and submitted to U.S. EPA in final form under separate cover within 60 days after operable unit startup. (1990 Consent Decree, Section VII, Subsection D-14).

- a. A draft O&M plan will be submitted to U.S. EPA for review and comment prior to startup.
- b. U.S. EPA's comment is noted, however, changes in the Consent Decree wording are negotiation issues that can be addressed under separate cover. No change has been made as per telephone conference with U.S. EPA, C. Cooper on November 6, 1991.
- c. Goodyear will incorporate U.S. EPA comments as needed to the SVE O&M manual, however, these changes are not part of the current deliverable. These changes can be negotiated if needed under separate cover.

Comment 26 Response

U.S. EPA's comment regarding the SVE O&M plan is noted and Goodyear agrees that the O&M plans presented in Appendices A and B are in draft form.

These appendices will be combined into a single SVE O&M document that will be submitted to U.S. EPA under separate cover as draft prior to system startup and as final within 60 days following startup.

A Field Sampling Plan and Quality Assurance Project Plan will be part of the submittal. M&E has included a draft of the Field Sampling Plan and Quality Assurance Project Plan in Appendix N of this document.

Comment 27 Response

- a. Appendix A

U.S. EPA's comments are noted. Appendix B has been prepared in draft form to develop current, polygon-specific data with respect to optimizing SVE system operation.

b. **Appendix F**

During SVE system startup, the parameters will be developed using a single well. Following the first couple days of operation, the remaining polygon wells will be brought on line using the parameters developed from the single well.

Bringing the SVE wells on line in a step-wise manner will allow for the proper flow and vacuum adjustment to develop the required radius of well influence.

Lastly, text in the document that conflicted with the U.S. EPA definitions of sub-area has been corrected.

Goodyear recognizes that a formal air discharge permit is not required from Maricopa County to operate the SVE system.

Goodyear has prepared the air permit application as a means to address the discharge requirements of Maricopa County.

The permit application will serve as a guide for discharge compliance during system operation.

Appendix F has been modified to reflect the system configuration as well as its intent.

Comment 27 Response (Second)

The SVE Final Design Document has been prepared for Polygon 79. This decision was mutually agreed to by Goodyear and U.S. EPA (C. Cooper) by teleconference on November 6, 1992.

The Construction Quality Assurance Project Plan was submitted in the September 10, SVE Final Design, Appendix C document and has not been addressed in this document revision.

Lastly, telephone conference with U.S. EPA (C. Cooper) on November 6, 1992 established that the specifications for the SVE system did not need to be submitted to U.S. EPA in this deliverable. This decision was part of the renegotiated Consent Decree startup date which excluded the system design specifications from the document submittal.

Comment 28 Response

U.S. EPA comment is noted and the emergency phone number list will be viably posed on and around the SVE operable unit once constructed.

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EXECUTIVE SUMMARY

Goodyear Tire and Rubber Company (Goodyear) contracted Metcalf & Eddy, Inc. (M&E) to prepare the SVE Operable Unit 90% Complete Conceptual Design for the remediation of vadose zone soils at the Phoenix-Goodyear Airport facility (PGA). The report is referred to as the SVE Final Design Document and provides the 90% complete conceptual design for the SVE operable unit for Polygon 79 in accordance with by the 1990 Consent Decree (Section VII, Subsection D-8).

Goodyear is required to prepare this SVE Operable Unit 90% Complete Conceptual Design as part of the overall site remediation effort agreed to in the Consent Decree between Goodyear and the U.S. EPA. Section VII (Subsection D-8, a-i, p. 20) of the Consent Decree requires that the SVE Operable Unit 90% Design be prepared to provide a 90% complete conceptual design of a Soil Vapor Extraction and Treatment System for the first sub-area that will remove the volatile organic contaminants (VOC) from the site vadose zone soils. The soils are required to be remediated to a level that will not degrade the underlying ground water in the Subunit A aquifer above the ground water clean-up levels for the VOCs presented in Table 2-5 of the September, 1989 Record of Decision for the Phoenix-Goodyear Airport (PGA) site. The MCL threshold ground water concentration for TCE is 5 $\mu\text{g/L}$.

The determination of whether a sub-area of the site will require SVE Operable Unit remedy is based on the results of the vadose zone contaminant transport models, VLEACH and Mixing Cell.

Sub-areas of the site, or polygons, have been modeled using the VLEACH and Mixing Cell model using both current (May, 1992) sub-area specific data as well as data from previous site investigations.

Sub-areas of the site found to result in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ are prioritized for SVE operable unit remedy or further investigation. Polygons that have current (1992) soil vapor data and result in Subunit A ground water degradation in excess of 5 $\mu\text{g/L}$ are

prioritized for SVE operable unit remedy. Polygons that contain only 1989 soil vapor data and are found to result in Subunit A ground water degradation in excess of 5 $\mu\text{g/L}$ are prioritized for additional investigation and VLEACH and Mixing Cell screening in accordance with the May, 1992 SVE Design Memorandum.

The five major objectives which are addressed in the SVE Operable Unit 90% Design are:

1. Present and discuss results of the May, 1992 SVE Design Memorandum Phase I/Phase II horizontal and vertical vadose zone investigation.
2. Present results of VLEACH and Mixing Cell polygon screening and polygon prioritization for SVE operable unit remedy and/or for further investigation.
3. Present Soil Vapor Extraction Operable Unit 90% Complete Conceptual Design for the first sub-area (Polygon 79) requiring SVE remedy as determined by VLEACH screening and prioritization.
4. Establish a field program and protocol to collect current, polygon-specific soil vapor data for polygons that do not have current soil vapor data and are resulting in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ as determined by VLEACH and Mixing Cell.
5. Establish a schedule for construction of the SVE operable unit for the first sub-area (Polygon 79) and concurrent collection of additional polygon soil vapor data.

Evaluation of the May, 1992 SVE Design Memorandum investigation results reveal that the present VOC mass in each of the four investigated polygons is significantly less than estimated in the 1989 RI/FS and its associated appendices (U.S. EPA). The contaminant mass estimate from the 1989 RI/FS for Polygon 92 was approximately 47,920 pounds as compared to the present delineated mass from soil vapor of 262 pounds. The 1989 contaminant mass estimate for Polygon 79 was approximately 375 pounds as compared to the present delineated mass from soil vapor of 282 pounds.

VLEACH and Mixing Cell modeling of the four investigated polygons (79,92,116, and 117) and the top 26 1989 investigated polygons results in a total of nineteen (19) polygons that result in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$. The polygons that were modeled were

prioritized in order of increasing impact to ground water. Polygons investigated in May, 1992 that failed the VLEACH modeling were prioritized for SVE remediation and polygons containing 1989 data were prioritized for additional Phase I/II investigation. Of the May, 1992 investigated polygons, Polygon 79 results in the greatest impact to Subunit A ground water and is therefore prioritized for SVE remedy first.

The SVE Operable Unit Final Design Report presents: the results of the most recent VLEACH modeling; the SVE Operable Unit 90% Complete Conceptual Design for Polygon 79; and the rationale and field program for additional polygon investigation. Each of these components are developed in the seven sections which include:

Section 1	Introduction
Section 2	Design Memorandum Investigation Results
Section 3	SVE Operable Unit 90% Complete Conceptual Design
Section 4	Phase I Shallow Soil Vapor Survey
Section 5	Phase II Deep Soil Vapor/Soil Boring Survey
Section 6	Residuals Management
Section 7	Schedule

These sections are briefly described below.

The May, 1992 Design Memorandum investigation was conducted to determine the vadose zone VOC concentrations in the four (4) most contaminated polygons at the PGA facility. These polygons include 79, 92, 116, and 117. The investigation was undertaken to determine the mass of VOC contaminants present for the purpose of designing the SVE Operable Unit treatment system as well as provide a baseline to evaluate remedial progress if SVE remedy is necessary. The May, 1992 Design Memorandum involved two primary investigation components, a shallow soil vapor investigation (Phase I), and a deep soil vapor investigation (Phase II). The Phase I investigation delineated the horizontal spatial distribution of shallow soil vapor and provided a means to locate potential VOC source areas within each polygon. Results of the Phase I soil vapor investigation revealed peak concentration areas within each of the four polygons which provided the location for the Phase II soil vapor investigation.

The Phase II soil vapor investigation included the advancement of one (1) boring in each of the four polygons to the top of the capillary fringe to collect soil and soil vapor samples for laboratory analysis. Soil samples were collected during the advancement of each of the borings and submitted to a certified physical soils testing laboratory for analysis. The vadose zone-specific physical soil parameters were developed for incorporation into the VLEACH model for polygon modeling and prioritization. A total of sixteen (16) soil samples were submitted for analysis.

Soil vapor samples were collected from four (4) vapor piezometers constructed in each of the four (4) polygon soil borings. The soil vapor samples were used to determine the current mass of VOC contaminants in the vadose zone for VLEACH modeling and prioritization and SVE Operable Unit Design. A total of sixteen (16) soil vapor samples were collected and submitted for laboratory analysis.

Results of the Phase I/II investigation revealed significantly less VOC mass in polygons 92, 79, 116, and 117 at present than was estimated in the 1989 RI/FS. VLEACH and Mixing Cell Modeling of the top 32 site polygons including the four investigated polygons using the current site-specific vadose zone physical soil data indicates that a total of seventeen (17) polygons result in potential Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$. VLEACH and Mixing Cell modeling of these polygons with the current VOC masses reveal that two of the four polygons, 116 and 117, do not require SVE Operable Unit Remedy as defined by Section VII, Subsection D-8 and Appendix B of the 1990 Consent Decree. Polygons 79 and 92 require SVE Operable Unit Remedy with Polygon 79 prioritized for treatment based on a greater ground water impact. Of the seventeen (17) polygons currently failing the VLEACH and Mixing Cell screening, fifteen (15) are required to be further investigated and screened using VLEACH and Mixing Cell.

The Soil Vapor Extraction Operable Unit 90% Complete Conceptual Design for Polygon 79 is presented to remediate site vadose zone soils in accordance with the 1990 Consent Decree. The SVE Operable Unit has been designed to treat one entire sub-area (or polygon) at a time. Additionally, the SVE Operable Unit has been designed to be mobil so that it can be moved from one polygon to another if required.

The SVE Operable Unit has been designed in accordance with state air quality regulations for solvent vapor treatment and utilizes off-site regenerated Granular Activated Carbon (GAC) for solvent removal at a flow rate of approximately 500 scfm at 15 inches of mercury vacuum. Additionally, the SVE Operable Unit has been designed for remote, fail-safe operation via telemetry unit and telephone lines to maximize efficiency and minimize system oversight.

Lastly, due to the results of the most recent VLEACH and Mixing Cell Polygon Screening and Prioritization, additional polygon vadose zone investigation is required to determine if SVE Operable Unit Remedy will be required in polygons other than 79 and 92.

A Phase I-shallow and Phase II-deep soil vapor investigation is proposed for nine (9) polygons (21A-26A, 113, 13A, 111, 96, 65, 38, 36, and 15A) not currently passing the VLEACH and Mixing Cell screening.

The Phase I-shallow investigation will develop the horizontal distribution of soil vapor within each of the four polygons and delineate the area of highest concentration for the location of the Phase II-deep soil vapor location for each polygon. The Phase I investigation will be carried out above and below the site caliche layer to evaluate if the caliche is providing a barrier to contaminant volatilization and detection above the caliche layer. To facilitate this evaluation, two soil vapor samples will be collected at each location, one from above the caliche and one from below the caliche layer. The area of highest VOC concentrations will provide the basis for the location of the Phase II investigation boring in each polygon.

The Phase II investigation will involve the advancement of a boring in each of the nine polygons to the top of the capillary fringe, the installation of four depth-discrete soil vapor piezometers in each boring, and the collection of soil vapor samples from each of the vapor piezometers. The Phase II soil vapor data will be used to execute the VLEACH and Mixing Cell model for the nine investigated and six contiguous polygons to determine if they could contribute to Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ and therefore require SVE Operable Unit Remedy. (1990 Consent Decree, Section VII, Subsection 6, p. 17) Polygons not investigated in May, 1992, or in

this investigation that continue to fail the VLEACH screening will be prioritized for Phase I/II investigation.

Section 6 of this Report describes the management of residuals developed on site as a result of site investigation and/or remedial activities.

Lastly, Section 7 of this SVE Operable Unit 90% Complete Conceptual Design details the schedule of tasks and deliverables to U.S. EPA for Compliance with the requirements of the 1990 Consent Decree. The current data from the four investigated polygons resulted in two of the four polygons (116 and 117) passing VLEACH and Mixing Cell, therefore, not requiring remediation and two polygons failing (79 and 92). Based on the decision parameters set up in the May, 1992 SVE Design Memorandum, Polygons 79 and 92 require SVE remedy with polygon 79 prioritized for treatment based on ground water impact. The refined VLEACH and Mixing Cell modeling also resulted in fifteen (15) additional polygons that fail or marginally fail VLEACH and Mixing Cell, therefore not requiring additional investigation and modeling.

As a result of Polygon 79 requiring SVE remedy, the schedule critical path is to meet the stipulated deadlines in the consent Decree of commencing construction within 60 days (Section VII, D-12) and the second deadline of commencing startup within 210 days (Section VII, D-13) following U.S. EPA approval of the final SVE Design. Concurrently, the Phase I and II investigation of the nine additional polygons that potentially require SVE remediation will have to be investigated and evaluated using VLEACH and Mixing Cell to determine which polygon(s) if any require remediation. Although there exists no formal deadline or timetable for the completion of the Phase I/II investigation work at the nine polygons, Goodyear will conduct the work in a manner that maximizes field effort time.

Once the nine polygons have been investigated, they and the six contiguous polygons will be screened using the VLEACH and Mixing Cell to determine if they require SVE remedy. Polygons passing the VLEACH and Mixing Cell screening will be removed from further investigation and remediation consideration. Polygons failing the VLEACH and Mixing Cell screening will be

prioritized for SVE remedy if investigated, or Phase I/II investigation if not investigated as outlined in the May 1992 SVE Design Memorandum.

Progress on the bidding and procurement for the long lead SVE system components will begin immediately following U.S. EPA approval of the Final SVE design.

Once the treatment plant has been installed and operation has commenced for Polygon 79, the investigated polygons that have failed the VLEACH and Mixing Cell screening will be prioritized for SVE remedy. Once the contaminant levels have been reduced in Polygon 79 to the allowable residual mass as determined through the use of VLEACH, the SVE operable unit will be moved to the next prioritized polygon for remediation if required. This process will continue until each of the polygons requiring SVE remedy have been treated in accordance with the 1990 Consent Decree and this document.

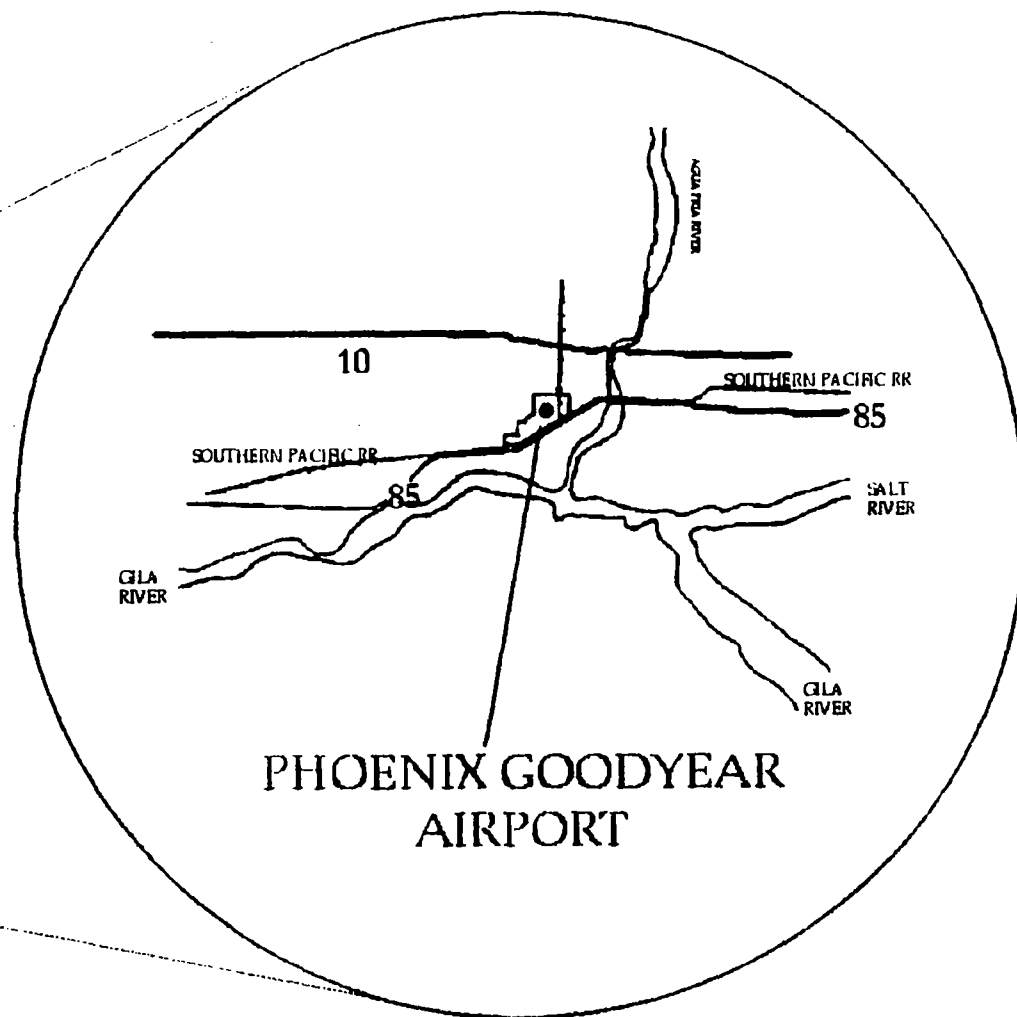
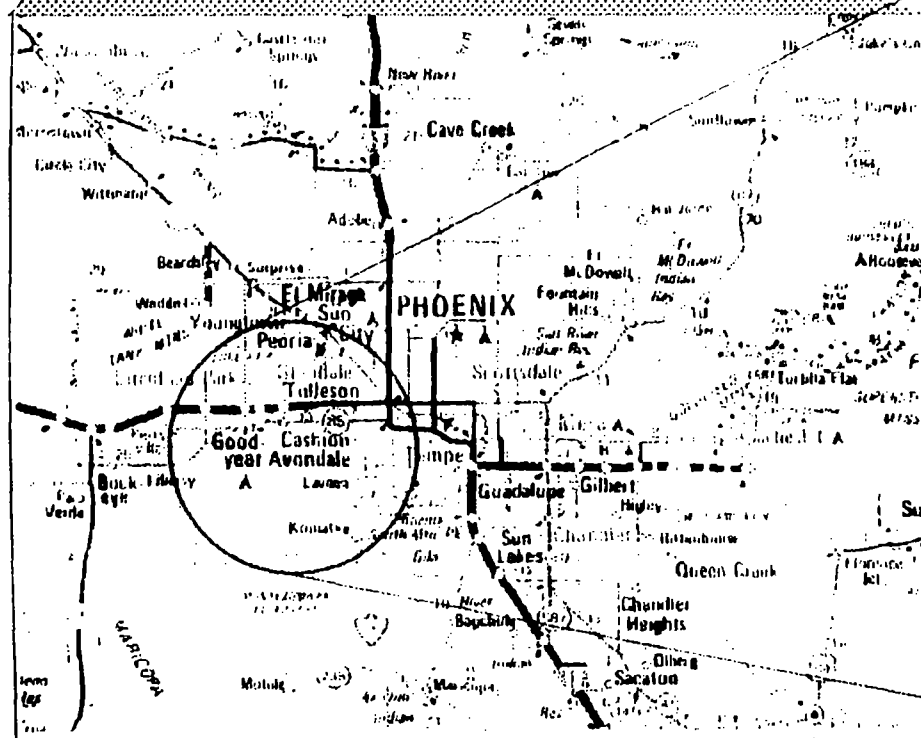
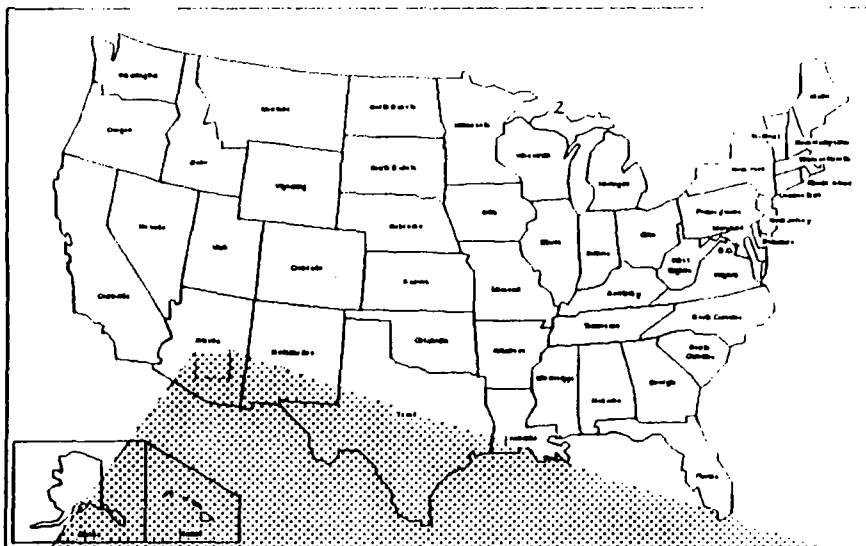
SECTION ONE

INTRODUCTION

This report is being submitted to the Goodyear Tire and Rubber Company (Goodyear) pursuant to the Civil action Consent Decree and in conformance with the Soil Vapor Extraction (SVE) operable unit remedy for soil remediation. The Consent Decree work will consist of the design, construction, operation, and maintenance of a soil vapor extraction unit(s) equipped with emission controls to remove VOC's from the vadose zone. Remediation will proceed where VOC residues pose a threat to ground water quality in Subunit A, as provided in the 1989 Record of Decision (ROD) and satisfies the requirements of Subparagraph C.6 and C.7 of Section VII and Appendix B of the Consent Decree. These areas include Target Area 2 as outlined in the ROD and polygons of elevated concentration. Polygons requiring SVE operable unit remedy will be determined using VLEACH subsequent to data collection as outlined in Sections 4 and 5 of this work plan. Figure 1-1 illustrates the location of the site and Drawing P-1 is a detailed map of the site. Drawing P-1 illustrates the total number of polygons on the site as well as Target Area 2. The site was divided up into regions for the 1989 U.S. EPA investigation (RI/FS, Vol. VI, Appendix S). These areas include Regions 1 through 4. Regions 1, 2, and 4 are considered to be uncontaminated with TCE. Region 3 contains the majority of the total mass and is therefore broken down into smaller sub-areas or polygons for finer delineation. This report specifically addresses and satisfies the requirements of the Consent Decree 90% Complete Conceptual Design of the final SVE remediation operable unit remedy for Target Area 2 and associated applicable polygons within Region 3.

The five major objectives of the Design Memorandum are:

1. Present and discuss results of the May, 1992 SVE Design Memorandum Phase I/Phase II horizontal and vertical vadose zone investigation.
2. Present results of VLEACH and Mixing Cell polygon screening and polygon prioritization for SVE operable unit remedy of further investigation.



PGA Site Location Map
Goodyear Phoenix Airport

Project Number
006791

Figure 1-1

3. Present Soil Vapor Extraction Operable Unit 90% Complete Conceptual Design for the first sub-area (Polygon 79) requiring SVE remedy as determined by VLEACH screening and prioritization.
4. Establish a field program and protocol to collect current, polygon-specific data for polygons that do not have current soil vapor data and are resulting in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ as determined by VLEACH.
5. Establish a schedule for construction of the SVE operable unit for the first sub-area and concurrent collection of additional polygon soil vapor data.

Evaluation of the May, 1992 SVE Design Memorandum investigation results reveal that the present VOC mass in each of the four investigated polygons is significantly less than estimated in the 1989 RI/FS and its associated appendices (U.S. EPA). The mass estimate from the 1989 RI/FS for Polygon 92 was approximately 47,920 pounds as compared to the present delineated mass from soil vapor of 262 pounds. Similarly, the 1989 RI/FS mass for Polygon 79 was 375 pounds compared with a current mass of 282 pounds.

Based on these results, this SVE Final Design document has been prepared for Polygon 79, because the current mass of VOCs in the vadose zone soils result in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ as determined by VLEACH and Mixing Cell Modeling.

The SVE Final Design report presents: the results of the most recent VLEACH modeling; the SVE Operable Unit 90% Complete Conceptual Design; and the rationale and field program for additional polygon investigation.

Sections 3 and 4 of the May, 1992 Soil Vapor Extraction (SVE) Final Remedy Design Memorandum highlighted the Phase I/II vadose zone soil vapor investigation of Polygons 92, 79, 116, and 117. These polygons were investigated to determine the present mass of VOC contamination for SVE Operable Unit design for the first sub-area and VLEACH and Mixing Cell screening.

The Phase I/II investigation was carried out in May and June of 1992 with U.S. EPA approval and oversight.

The Phase I investigation delineated the spacial distribution of shallow soil vapor in the vadose zone for each of the four polygons (92, 79, 116, 117). Isoconcentration maps of the Phase I data were prepared and submitted to the U.S. EPA for review and approval of the Phase II investigation locations. The Phase II investigation locations were proposed on the location within each polygon that demonstrated the highest shallow soil vapor concentrations.

The Phase II soil vapor investigation included the advancement of one (1) boring in each of the four polygons to the top of the capillary fringe to collect soil and soil vapor samples for laboratory analysis. Soil samples were collected during the advancement of each of the borings and submitted to a certified physical soils testing laboratory for analysis. The vadose zone-specific physical soil parameters were developed for incorporation into the VLEACH model for polygon modeling and prioritization. A total of sixteen (16) soil samples were submitted for analysis.

Soil vapor samples were collected from four (4) vapor piezometers constructed in each of the four (4) polygon soil borings. The soil vapor samples were used to determine the current mass of VOC contaminants in the vadose zone for VLEACH modeling and prioritization and SVE Operable Unit Design. A total of sixteen (16) soil vapor samples were collected and submitted for laboratory analysis.

Results of the Phase I/II investigation were significantly less VOC mass in polygons 92, 79, 116, and 117 at present than was estimated in the 1989 RI/FS.

Section 4 of the May, 1992 SVE Design Memorandum details procedures for VLEACH and Mixing Cell screening of the four investigated polygons (92, 79, 116, and 117) as well as the remaining 75 polygons that did not pass the initial conservative polygon screening. (Design Memorandum, Section 2.2.2.2).

Results of the VLEACH and Mixing Cell modeling conducted with the May, 1992 soil and soil vapor data indicate that two (2) polygons result in potential Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ and require SVE remedy. These polygons include Polygon 79 and 92. In

addition to the two investigated polygons, fifteen (15) additional, non-investigated polygons also failed the VLEACH and Mixing Cell screening.

In accordance with the 1990 Consent Decree (Section VII, Subsection D-6 and Appendix B), two of the four polygons investigated as outlined in the May, 1992 Design Memorandum, Polygons 116 and 117, will not require SVE Operable Unit remedy, and two polygons, 79 and 92 will require SVE remedy. This conclusion is based on the fact that the residual mass of VOCs in two of the polygons are not sufficient to cause ground water concentrations in excess of 5 $\mu\text{g/L}$, the U.S. EPA site ground water maximum contaminant level. In accordance with Appendix B of the 1990 Consent Decree, two of the four investigated polygons, 116 and 117, each contain an inventory of VOC mass that is allowable within the conditions of the Consent Decree. This VOC mass is referred to as the Allowable Residual Mass (ARM).

Based on these results, the SVE Operable Unit 90% Complete Conceptual Design has been prepared for the highest prioritized polygon from this round of VLEACH and Mixing Cell screening. The SVE 90% Design has been prepared for Polygon 79.

As outlined in Section 1 of the May, 1992 SVE Design Memorandum, the determination of implementation of SVE Operable Unit Remedy in a particular polygon is to be based on current soil vapor VOC data. These data provides the basis for: system treatment configuration, carbon usage, and it provides a baseline VOC inventory for the polygon with which SVE remediation progress can be measured.

Section 2 of this report details the results of the field investigation carried out in May and June, 1992 in accordance with Sections 3 and 4 of the Design Memorandum. Section 2 also describes the results of the VLEACH, and Mixing Cell screening of the top 32 of the 79 site polygons (92, 79, 116, 117, and 28 non-investigated polygons). The results of the VLEACH and Mixing Cell screening are then prioritized with respect to posing the greatest threat to Subunit A ground water quality. Polygons that have undergone current (1992) vadose zone investigation have been prioritized for SVE remedy if required. Polygons resulting in Subunit A ground water concentrations in excess of 5 $\mu\text{g/L}$ as

determined by VLEACH using 1989 RI/FS data have been prioritized for Phase I/II investigation (Section 4 and 5) VLEACH and Mixing Cell Screening, and SVE remedy prioritization as stated in Section 1 of the May, 1992 Design Memorandum.

Section 3 of this report details the design criteria and considerations for the SVE Operable Unit. Each component of the SVE Operable Unit is described in detail from the soil vapor extraction wells, through the system piping, vapor treatment, and the electronic system controls. Appendix K of this document contains the draft plans and specifications for the SVE Operable Unit. Appendices A and B of this report detail the operation and maintenance of the SVE operable treatment system and extraction wells, respectively. Appendix C provides the quality assurance documentation of system construction, while Appendices E and F address the issues of draft easements and system permitting.

The SVE 90% Complete Conceptual Design has been prepared for the most highly prioritized, investigated polygon, 79. Once remediation activities are complete at Polygon 79, the SVE unit will be moved to the next polygon requiring SVE remedy. The polygon demonstrating the greatest impact to Subunit A groundwater quality will be selected first. The results of the current VLEACH and Mixing Cell modeling indicate that Polygon 92 will require SVE remedy following Polygon 79. Should additional Phase I/II investigation and VLEACH screening cause a polygon to result in greater Subunit A ground water impact, the polygon will be prioritized for SVE remedy over Polygon 92. Polygons, that have not been investigated in accordance with the U.S. EPA-accepted SVE Design Memorandum will be is scheduled for Phase I/II investigation and subsequent VLEACH and Mixing Cell screening as outlined in Sections 4 and 5 of this report in accordance with the procedures detailed in the SVE Design Memorandum.

Results of the VLEACH and Mixing Cell screening will dictate whether the ARMs for the investigated polygons have been exceeded and require SVE remedy (1990) Consent Decree, Section VII, Subsection D).

All sections of this Design Memorandum report are prepared in conformance with the 1990 Consent Decree, the 1989 ROD, and their associated appendices for the remediation of the vadose zone soils in associated polygons within Region 3 at the Phoenix-Goodyear Airport.

Remediation will be performed on applicable sub-areas of the site so that the vadose zone within the sub-area shall not cause VOC concentrations in Subunit A ground water to exceed the ground water cleanup levels identified in Table 2-5 of the 1989 ROD based upon application of the VLEACH model or similarly U.S. EPA-approved vadose zone model and the Mixing Cell ground water model. (See Section IV, p. 5 of the 1990 Consent Decree.) The threshold concentration for the target compound, TCE, is 5 $\mu\text{g/L}$ in water. SVE operable unit remedy will be applied to an entire polygon that has the potential of creating ground water concentrations in excess of 5 $\mu\text{g/L}$ in the Subunit A aquifer as determined by VLEACH and Mixing Cell. The area of influence, and therefore the number of wells required for the remediation of the first polygon (Polygon 79) has been determined by the data contained in Appendix S of the 1989 RI/FS and in the 1989 ROD. These data will be modified accordingly as operational data from the first sub-area becomes available.

In addition to the restrictions and requirements listed in the Consent Decree, this report and all associated appendices are in conformance with the provisions of CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act of 1980 142 U.S.C. Section 9601 et. seq. and the amendment: SARA, Superfund Amendment and Reauthorization Act of 1986 Pub. L. 99-499, 101 Stat. 1613 (1986).

The following sections of this SVE 90% Complete Conceptual Design outline Goodyear's and M&E's approach to the design of the design of the SVE operable unit and additional vadose zone site investigation for development of data for subsequent VLEACH polygon screening, and prioritization as well as the final SVE operable unit remedy and will be used as a remediation baseline. Section 7 provides a complete work scope and deliverable schedule for each of the tasks contained in this SVE 90% Complete Conceptual Design.

The SVE 90% Complete Conceptual Design sections include:

- Section 1 - Introduction
- Section 2 - Design Memorandum Results
- Section 3 - SVE Operable Unit 90% Complete Conceptual Design
- Section 4 - Phase I Shallow Soil Vapor Survey
- Section 5 - Phase II Deep Soil Vapor/Soil Boring Survey
- Section 6 - Residuals Management
- Section 7 - Schedule

Each of these sections follow.

SECTION TWO

PHASE I AND PHASE II INVESTIGATION/DATA ANALYSIS

Section 2 describes the sampling methods and results of the field work conducted in May 1992 as well as the analysis of that data. The data was analyzed through use of the VLEACH and Mixing Cell models to determine which of the 32 screened polygons will require remediation. Section 2.1 describes the methods and data generated during the May 1992 field effort, Section 2.2 describes the analysis of the investigation data. Section 2.3 identifies the prioritization of the screened polygons for subsequent investigation and/or remediation.

2.1 SAMPLING AND DATA OBJECTIVES

The objectives of the field work conducted in May 1992 were to collect field data in the (anticipated) four most contaminated polygons in preparation for the design of the SVE remediation system for the first polygon. Additionally, physical soil data was collected to more accurately determine some of the physical parameters that were previously estimated. These data were evaluated using the VLEACH and Mixing Cell models to prioritize the remediation of the polygons that would result in ground water concentrations in excess of the site cleanup level of 5 $\mu\text{g/L}$.

In May and June of 1992, M&E conducted a phased field investigation to characterize the vertical and lateral extent of TCE contamination in soil vapor at four polygons (92, 116, 117, and 79) at the PGA site. These four polygons were demonstrated to fail the initial screening tests as detailed in Section 2 of the May, 1992 Design Memorandum including VLEACH and Mixing Cell. From the four polygons highlighted in this investigation, M&E collected soil vapor samples from vapor probes mechanically driven into the shallow subsurface at four predetermined locations in each of the four polygons (sixteen total locations). All collected soil vapor samples were immediately analyzed in the field using a gas chromatograph.

Analytical data generated from these sample analyses was contoured in the field using a kriging technique on a computer. Kriging is a geostatistical technique which is best described as a family of methods used for the purpose of optimal nonlinear spatial prediction. The kriging technique employs a form of weighted averaging in which the weights are chosen such that the error associated with predictors is less than that for any other linear sum. The weights depend upon the location of the points used in the prediction process and upon their covariation.

Golden Software, Inc. Surfer program (version 4) was used for kriging the soil vapor survey data to generate contoured maps of Phase I Investigation data in each of the four polygons. The generated contour maps were used to determine the location of the greatest soil vapor concentrations within each Phase I investigated polygon. Based on these data, following U.S. EPA site investigator concurrence, a Phase II boring was positioned at the location predicted to be the highest TCE or combined TCE/DCE concentration within each of the four polygons. Both TCE and DCE are used for site analytical purposes because they have the lowest Maximum Contaminant Level (MCL) in drinking water (5 and 6 $\mu\text{g/L}$, respectively) and are the most predominant contaminants in the site soil vapor. The use of the Phase I lateral shallow soil vapor survey was used solely to determine appropriate Phase II investigation locations and was not used as a means of estimating VOC masses in the vadose zone.

Conducting the field investigation in phases provided data for more accurate and representative VLEACH and Mixing Cell screening as well as aid in the preparation of the 90% Complete Conceptual Design of the SVE operable unit remedy for the first polygon within the U.S. EPA Consent Decree (1990) timeframe. It also provided for the development of a more complete and focused investigation of polygons failing the refined VLEACH and Mixing Cell screening (Class 2 polygons). The refined VLEACH and Mixing Cell Screening was conducted on the polygons failing the May, 1992 Design Memorandum Method I polygon screening.

Screening Method #1 utilized a total mass dissolution approach where estimates of the total mass of TCE (revised estimate of VOC mass at the PGA Superfund site, Goodyear, AZ, U.S. EPA, 1989, based on a fully distributed case) existing in the vadose zone of a given polygon was input directly

into the ground water column beneath the contaminated soils. If the resultant ground water TCE concentration was calculated to be less than the established action level of 5 $\mu\text{g/L}$, the polygon was considered to have passed the screening test and was designated as a Class 0 polygon. Employing this screening test to the original 143 polygons resulted in 63 polygons passing (Class 0), and 80 polygons failing (Class 1).

The original 80 polygons that failed the Method 1 screening test actually total 79 polygons, as Polygon 27, originally considered as a separate, distinguishable polygon, is in fact grouped with the combined polygon 26-29, 32-35.

The refined VLEACH and Mixing Cell Screening used vadose zone- specific physical soil parameters as well as current depth-specific soil vapor data. Following the investigation of the first four (4) polygons, the results of the refined VLEACH and Mixing Cell screening established a revised prioritization of the screened polygons. Polygons that have been investigated as outlined in the May, 1992 Design Memorandum and fail the refined VLEACH and Mixing Cell screening (Class 2 polygons) were reprioritized for SVE remedy with the most contaminated polygons receiving the highest priority. Polygons passing the refined VLEACH and Mixing Cell screening (Class 1 polygons) that have been investigated as detailed in the 1992 Design Memorandum were dropped from further investigation or SVE remedy consideration. Those polygons not investigated in May, 1992 but screened with VLEACH and Mixing Cell using the refined soil physical data (Section 2.1) and the 1989 RI/FS contamination concentration and vertical distribution data and still fail VLEACH and Mixing Cell were prioritized for subsequent Phase I/II investigation.

The methodology employed for the May, 1992 field investigation and scope of work is presented in the following sections.

2.1.1 Soil Vapor Sampling Locations/Methodology

In order to determine the area of highest TCE and DCE concentrations within the four prioritized polygons highlighted in this investigation (92, 79, 116, 117), M&E conducted a phased investigation

of the polygons. This phased investigation consisted of two primary phases. Phase I evaluated the present shallow TCE and DCE soil vapor concentrations specifically across the four polygons and Phase II developed a vertical distribution of TCE and DCE soil vapor within the vadose zone. This survey was designed to assess the current levels of TCE in soil vapor for refined VLEACH and Mixing Cell screening as well as Soil Vapor Extraction operable unit (SVE) design purposes to supplement the 1989 RI/FS soil vapor data. Specifically, M&E conducted the Phase I soil vapor survey on polygons 92, 116, 117, and 79, to generate a contoured soil vapor concentration map of each investigated polygon which indicated the area within each polygon that is expected to contain the greatest soil vapor concentrations at depth. This data was then used for the purpose of scientifically establishing the location of the proposed Phase II boring that will likely intersect vadose zone soils which exhibit the greatest VOC concentrations within each of the four polygons.

The soil vapor survey was conducted in two phases, the first phase, Phase I, (Section 2.1.2) developed the lateral distribution of soil vapor over the polygons and was limited to a depth of 7.5-10 feet below grade. The second phase, Phase II, (Section 2.1.3) developed a vertical profile of soil vapor concentrations from the ground surface to the water table/capillary fringe through the installation of a soil boring and depth-discrete soil vapor monitoring wells for each of the four polygons.

2.1.2 Phase I Horizontal Investigation Description

Phase I of this investigation involved shallow (7.5-10 foot depth) soil vapor sampling at three locations, spacially distributed throughout the polygon so as to maximize areal coverage. One additional probe was roughly coincident with the vapor probe survey conducted during the 1989 RI/FS investigation. Phase I was designed to objectively determine the location of the highest TCE and DCE concentrations in the shallow vadose zone for the purpose of locating the Phase II soil boring.

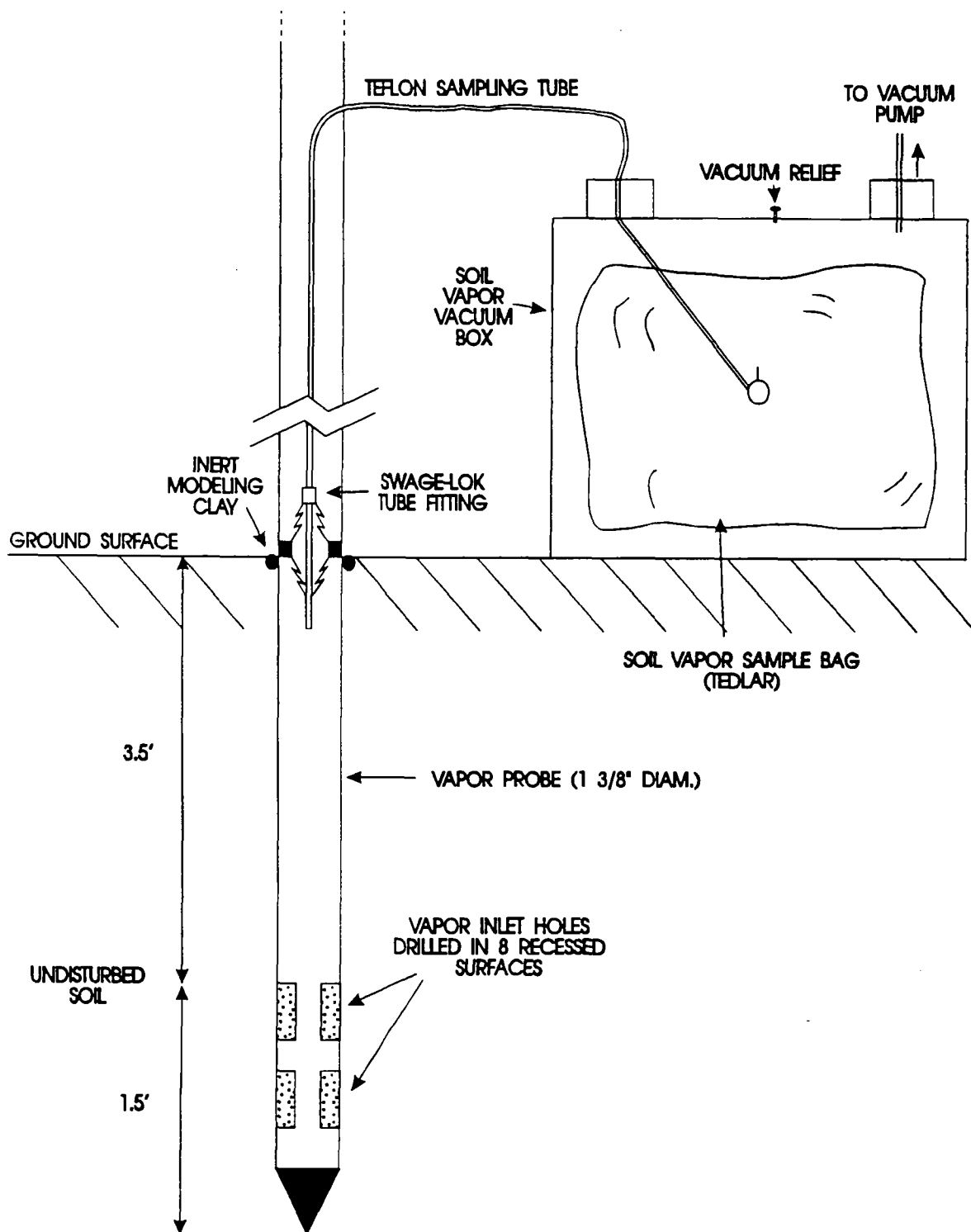
Prior to initiating sampling activities, M&E had the nodes of the four polygons and proposed sampling locations marked by a state-registered surveyor. Delineation of polygon boundaries and

sampling locations permitted the field crew to accurately determine the distance to polygon boundaries and to move proposed sampling locations relative to polygon boundaries where access problems existed due to structures or subsurface utilities. By increasing the shallow soil vapor database fourfold, greater sample validity and areal coverage within the four polygons was obtained. The additional vapor probes were located within each polygon using a combination random/systematic approach in positioning probes with the end objective of maximizing areal coverage within each investigated polygon.

The goal of this initial investigation was to maximize the characterization of shallow, subsurface TCE and DCE concentrations in soil vapor within each Class 2 polygon using a limited number of additional soil vapor probes for the optimal location of the Phase II soil boring. Refer to May, 1992 SVE Design Memorandum for Polygon Classification.

2.1.2.1 Soil Vapor Probe Emplacement

The shallow soil vapor probes were driven using a truck-mounted hydraulic punch system with a percussion hammer assist. Vapor probe rods were constructed of 5 foot lengths of threaded hardened steel alloy. The probe assembly is equipped with small diameter (1/16th-inch) vapor inlet holes drilled through eight recessed, machined surfaces; a machined, threaded drive point at the leading end; and a gas-tight Swage-Lok tubing fitting at the upper probe assembly. The recessed, vapor inlet hole configuration establishes a small annulus to remain between the hole wall and the probe, effectively preventing clogging. The rod assembly was driven to 3 to 5 feet below ground surface at an identified sampling location within a polygon, the drive hammer raised, and a second rod segment was threaded onto the probe assembly and driven until the sampling depth of 7.5-10 feet is reached. The Teflon (PTFE) sampling tubing attached to the upper probe was of sufficient length to be directed upwards through the rods, remaining accessible to sampling above ground surface. Figure 2-1 illustrates the soil vapor probe construction.



SOIL VAPOR SAMPLING PROBE
WITH VACUUM BOX

M&E Metcalf & Eddy

Drawn by:
J. Weldmann

Job
Number:
006791

Date:
September 1992

Checked by:
S. Zachary

Figure Number:
2-1

2.1.2.2 Soil Vapor Sample Collection

A segment of new Teflon (PTFE) tubing attached to the vapor probe was connected to the vacuum pump intake. Prior to sampling and purging, the system was leak tested using a soap solution. No leaks were detected during the investigation. A low flow rate, high vacuum, diaphragm pump was activated for a time period appropriate to purge approximately two open volumes of the sampling system. Vacuum from the sampling system was monitored during purging and sampling to prevent over pumpage. During the investigation, continuous monitoring of purged vapor through the use of a photoionization detector indicated that approximately 1.7 open volumes was sufficient to obtain maximum vapor concentrations. The total volume of sample removed during purging was recorded by a computer-controlled mass flow meter positioned between the pump and the tubing. Immediately following purging, the tubing was sealed off preserving the vacuum and allowing soil vapor to begin to migrate into the evacuated soil pores while preventing ambient air from entering the exposed tubing and dilute the soil vapor.

When the vacuum instrument returned to its ambient reading (pressure prior to pumping), the pump was reactivated and a soil vapor sample was taken between the pump and the vapor probe by collecting the gas sample in a three-liter capacity Tedlar bag. Because of potential volatile losses from samples collected at the discharge end of a pump, M&E used a soil vapor vacuum box. This technique utilizes the generation of a vacuum within a vacuum box, which reduces air pressure around the Tedlar bag through pumping. This results in a non-intrusive flow of the soil vapor sample (which is connected to the vapor probe tubing) into the bag as pressures within the vacuum box begin to equalize with the Tedlar bag. Figure 2-1 presents a schematic diagram of the soil vapor probe and vacuum box sampling assembly. Periodically, for QA/QC purposes, real time duplicate soil vapor samples were collected from vapor probes. The vacuum instrument must read less than 20% of maximum vacuum during soil vapor purging. Because of the relatively low vacuums recorded during purging/sampling, M&E interprets the native materials to be readily amenable to soil vapor transport and collection.

2.1.2.3 Soil Vapor Analysis

All Soil vapor samples collected from the four polygons during the Phase I sampling activities were collected in three-liter capacity Tedlar bags and immediately forwarded to the mobile laboratory equipped with a gas chromatograph (GC) for analysis (see Appendix B of the Design Memorandum). Reported soil vapor concentrations were in units of ppbV. The four VOC's detected in the subsurface at the PGA site (PCE, TCE, 1,1-DCE, and 1,1,1-TCA) were summed to provide a total VOC concentration as TCE. Table 2-1 presents a summary of the Phase I lateral soil vapor analytical results. The data were generated from the Phase I investigation and then compiled and contoured for each polygon.

A marker was set for the proposed Phase II soil boring at the location where the TCE concentrations were highest based on the contoured data. Placement of the Phase II boring was agreed upon in the field with M&E and U.S. EPA field oversight personnel.

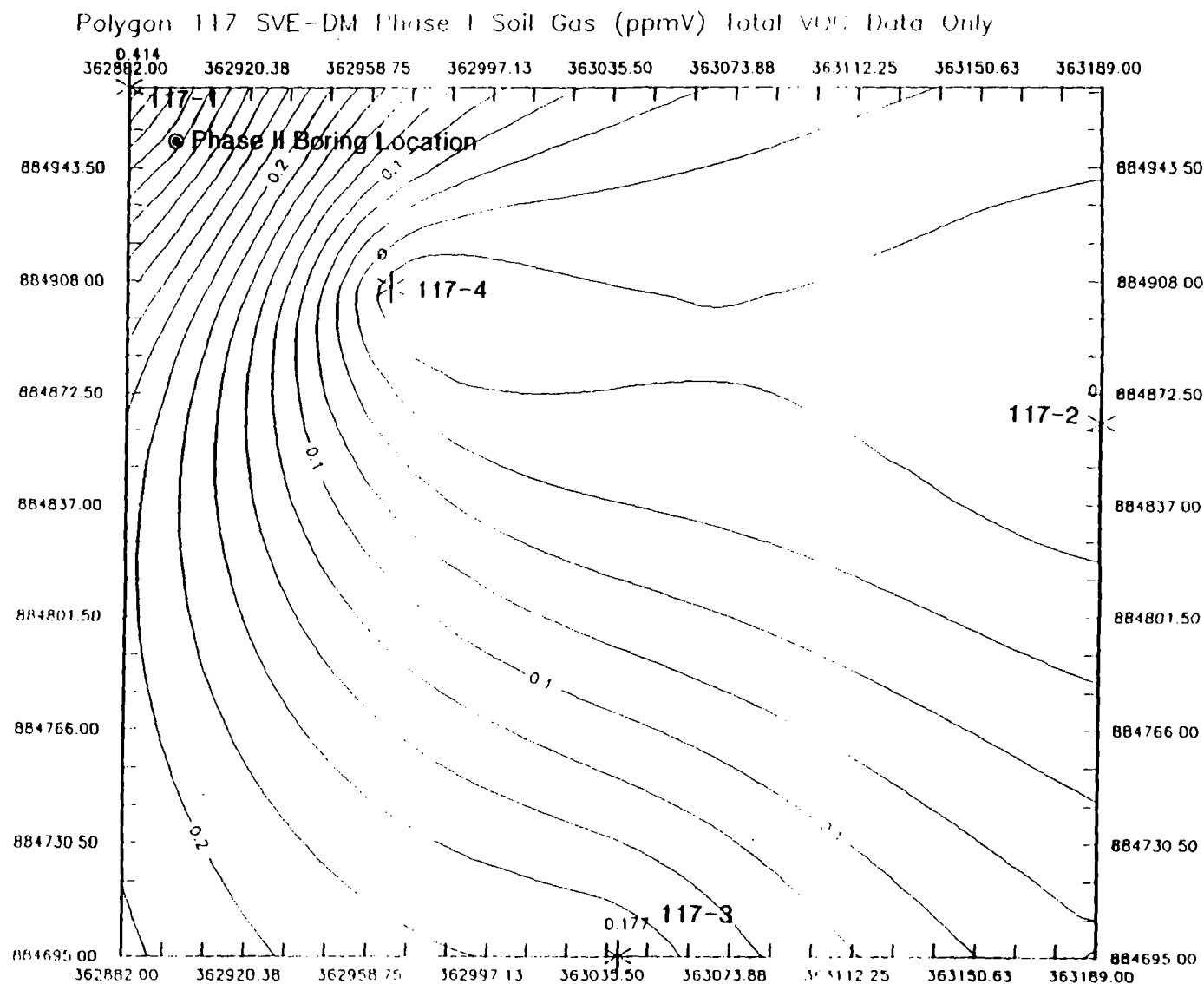
2.1.3 Phase II Vertical Investigation

Upon completion of the Phase I horizontal investigation work, lateral iso-concentration contour maps of contaminant vapor using statistical kriging methods were completed for each of the four polygons. Figures 2-2a through 2-2i present contoured plots of Phase I soil vapor analytical data for the four polygons investigated showing Phase II boring locations. Based on these data, a consensus for the proposed Phase II boring location was arrived at in the field between Goodyear and U.S. EPA field oversight personnel. Following this decision, the Phase II investigation began, which involved drilling a single soil boring located at the highest concentration contour within each of the four listed polygons (92, 79, 116, and 117). Phase II sampling addressed characterization of the vertical distribution of site soil contamination.

A single soil boring was drilled from ground surface to just above the present elevation of the capillary fringe and ground water table in each of the four polygons (92, 116, 117, and 79) using a hollow-stem auger drilling rig. The location of each soil boring was within the area of detected

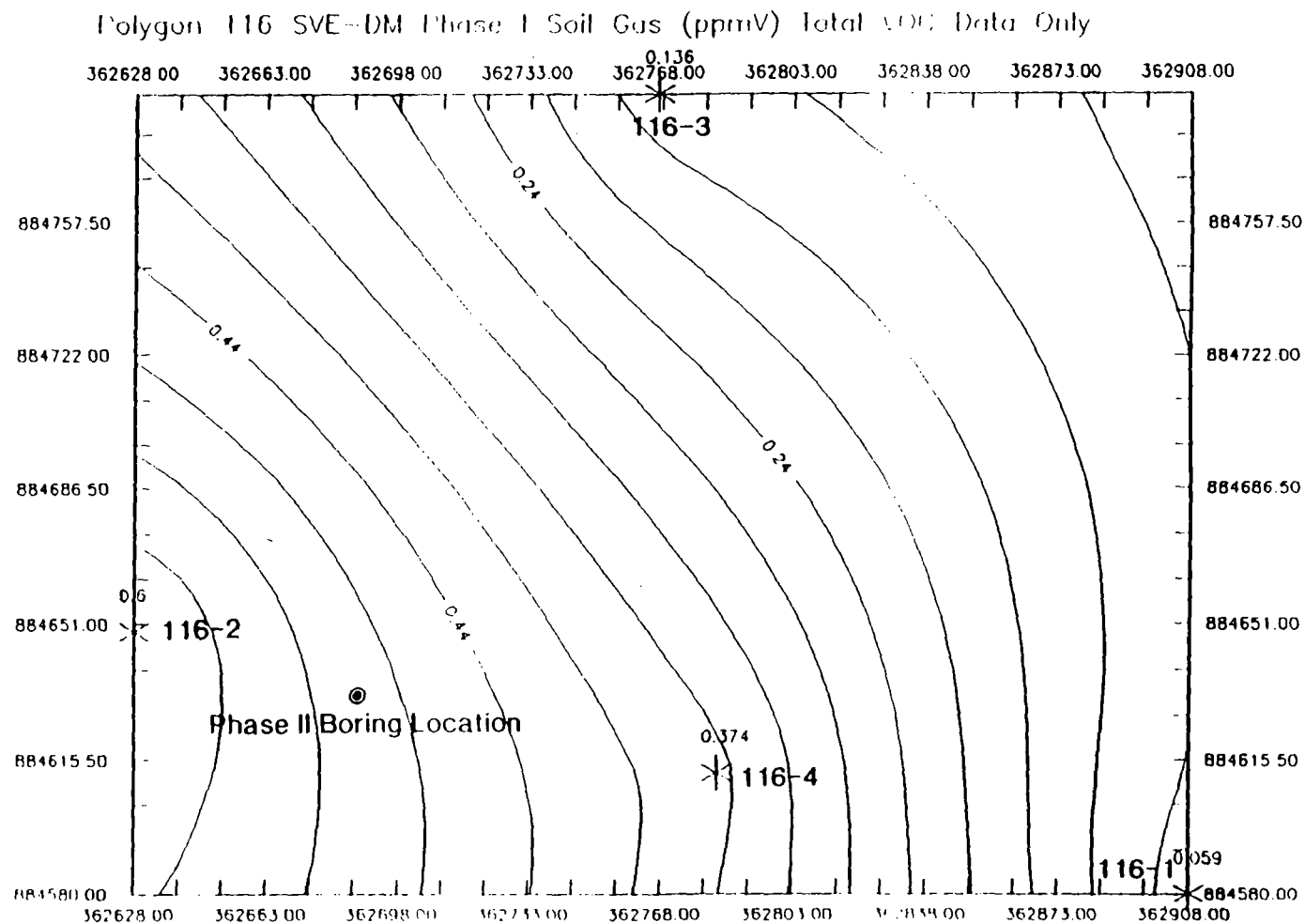
Table 2-1**SUMMARY OF PHASE 1 HORIZONTAL SOIL VAPOR PROBE
SURVEY FIELD LAB ANALYTICAL RESULTS**

Sample Location	Field GC Concentration (ppmV)				
	TCE	DCE	PCE	TCA	TOTAL
79-1	8.50	61.00	0.00	0.00	69.50
79-2	26.45	43.08	0.76	0.31	70.60
79-3	13.36	93.85	0.00	0.00	107.21
79-4	3.60	146.00	0.00	0.00	149.60
92-1	0.30	76.50	0.08	0.00	76.88
92-2	0.52	15.89	0.01	0.00	14.43
92-3	0.20	8.12	0.33	0.00	8.65
92-4	0.50	12.88	0.01	0.00	13.39
116-1	0.00	0.06	0.00	0.00	0.06
116-2	0.00	0.60	0.00	0.00	0.60
116-3	0.00	0.14	0.00	0.00	0.14
116-4	0.00	0.29	0.08	0.00	0.37
117-1	0.00	0.41	0.00	0.00	0.41
117-2	0.00	0.00	0.00	0.00	0.00
117-3	0.00	0.00	0.18	0.00	0.18
117-4	0.00	0.00	0.00	0.00	0.00



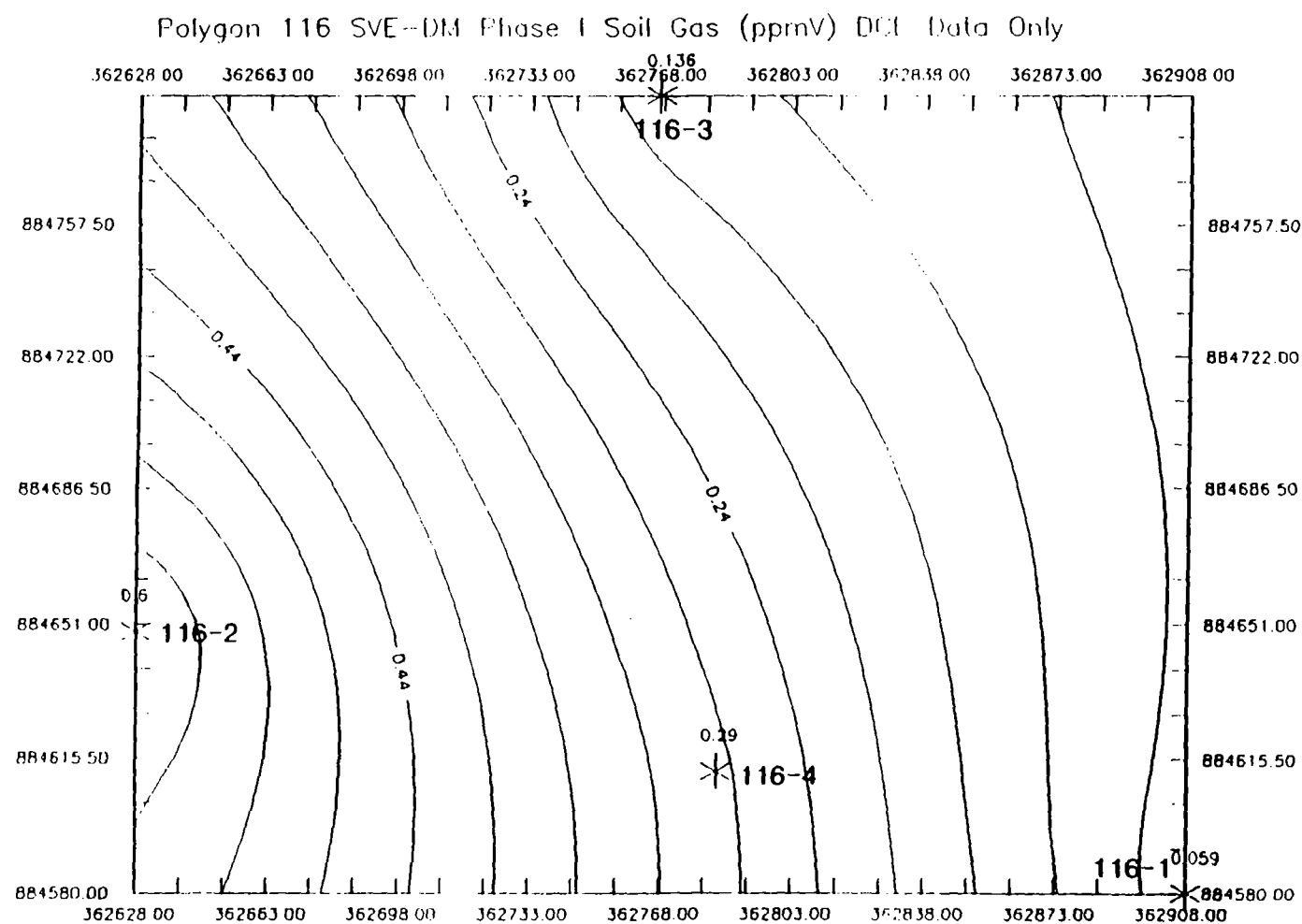
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2a



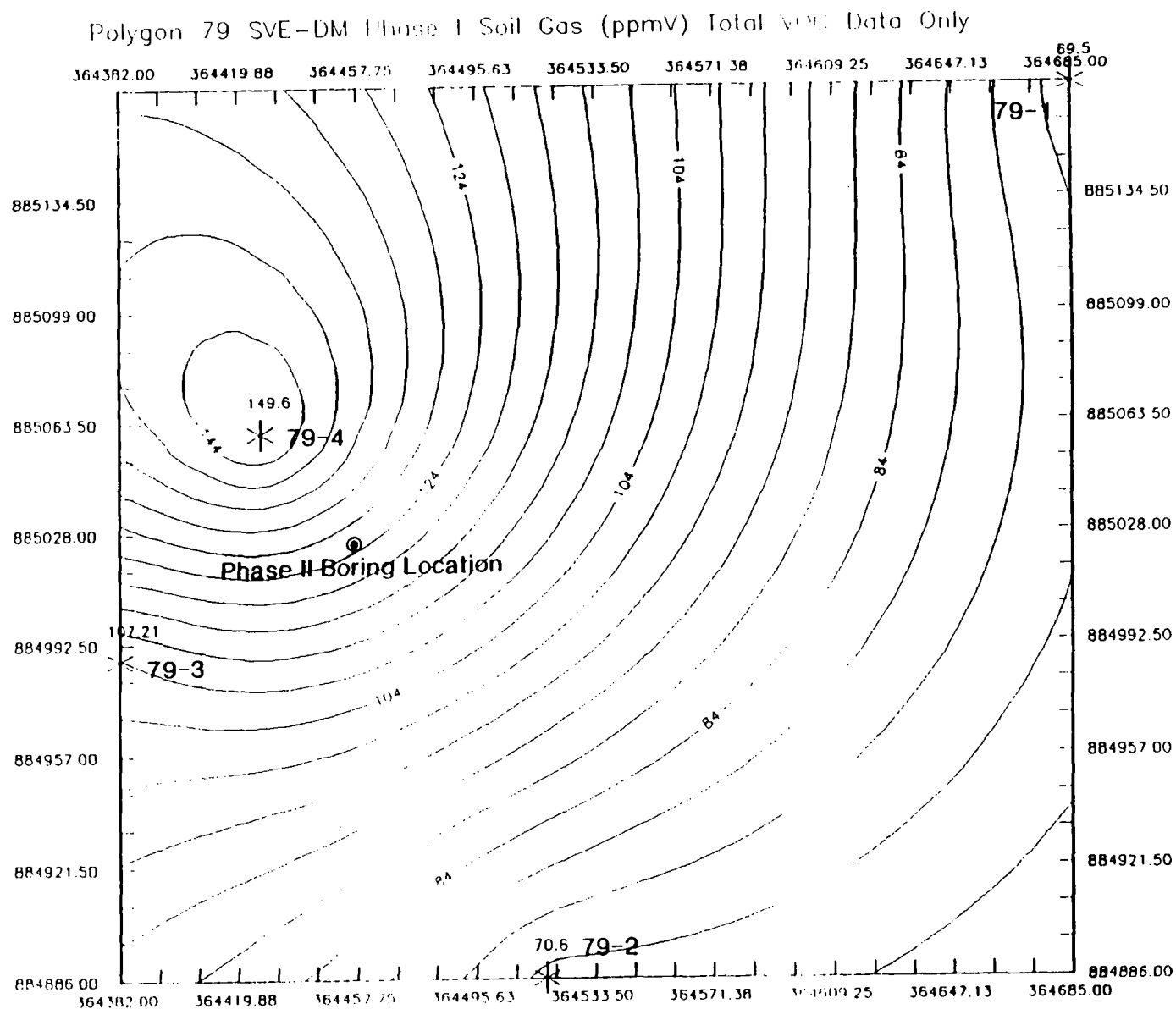
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2b



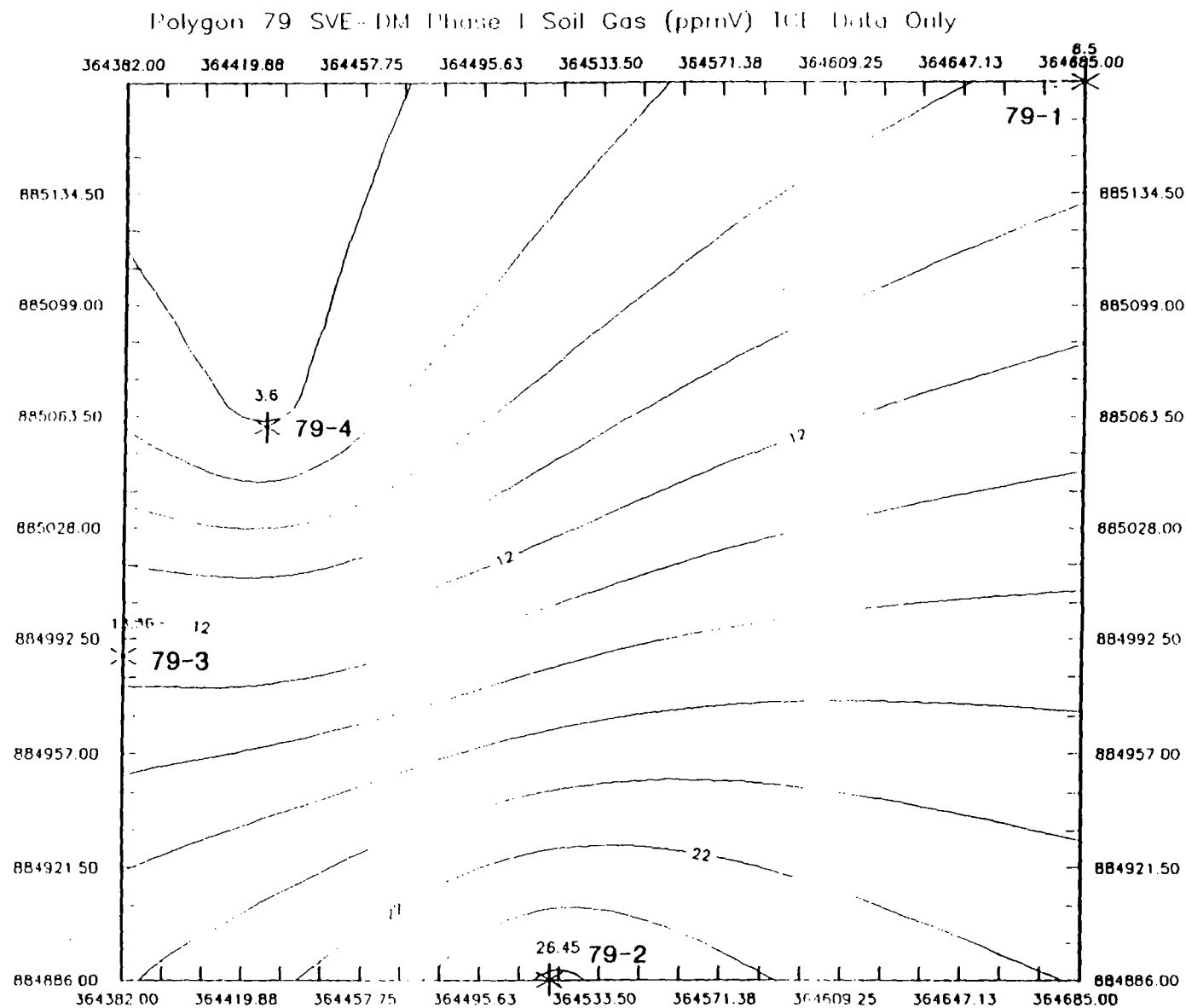
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2c



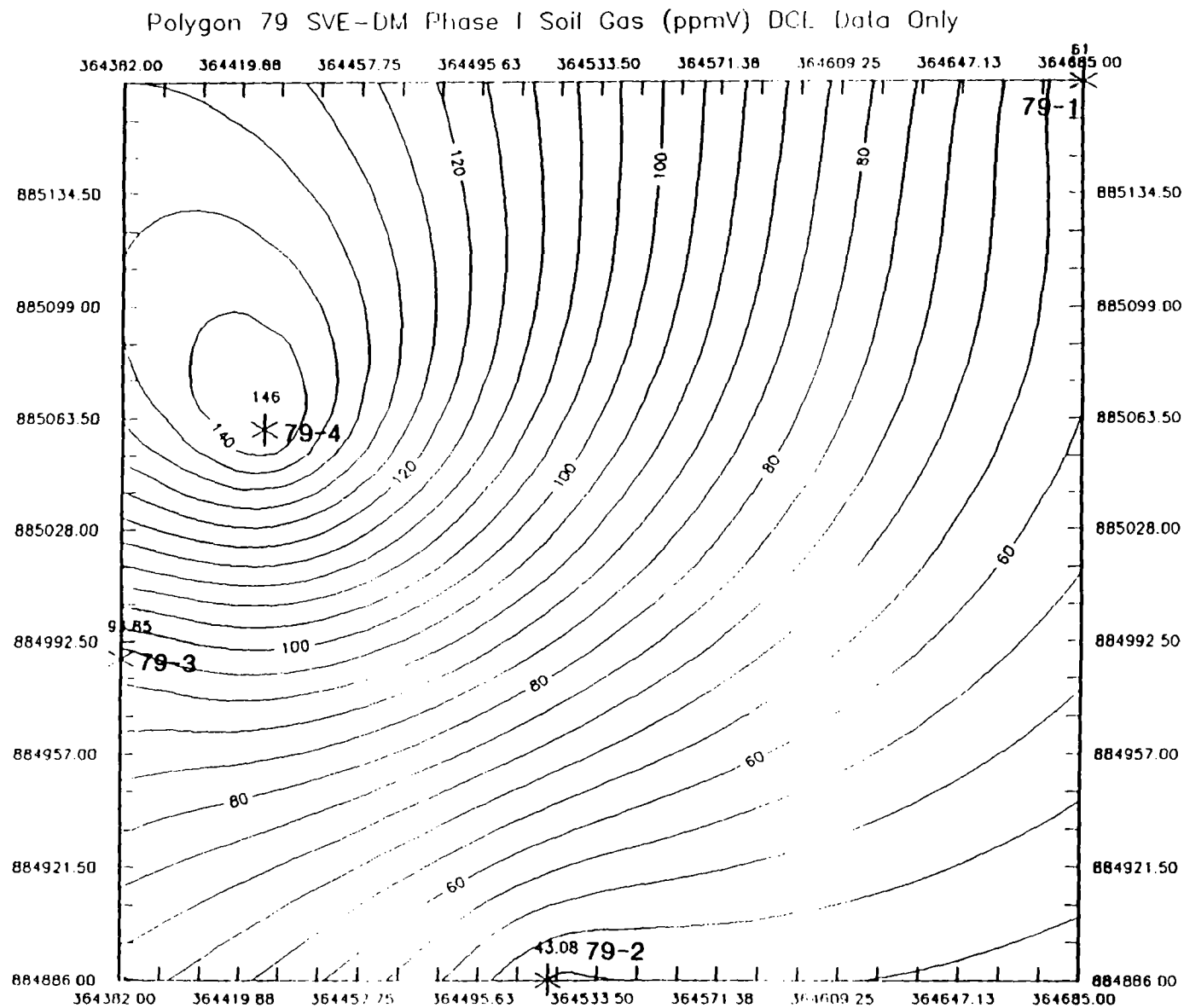
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2d



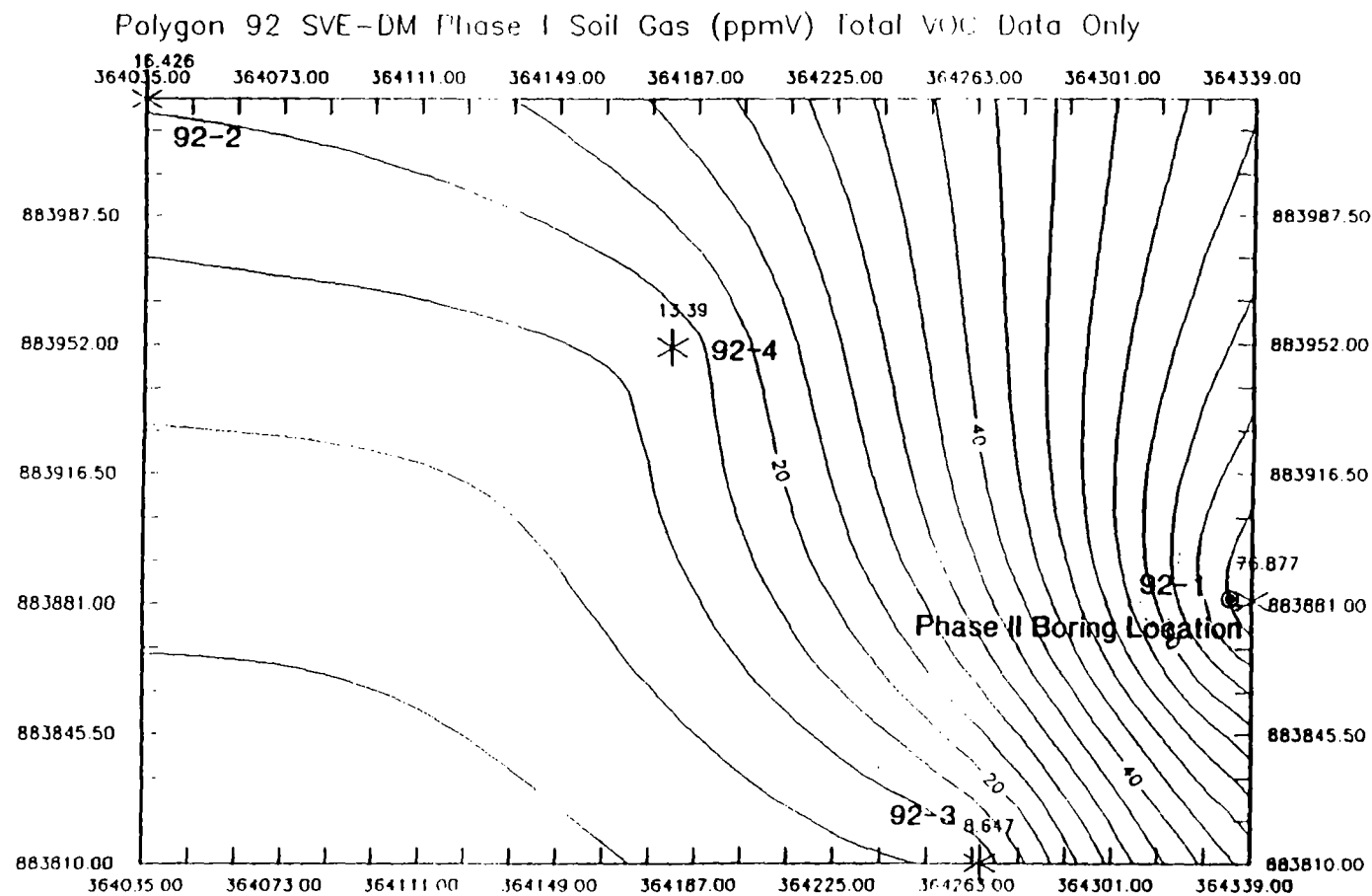
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2e



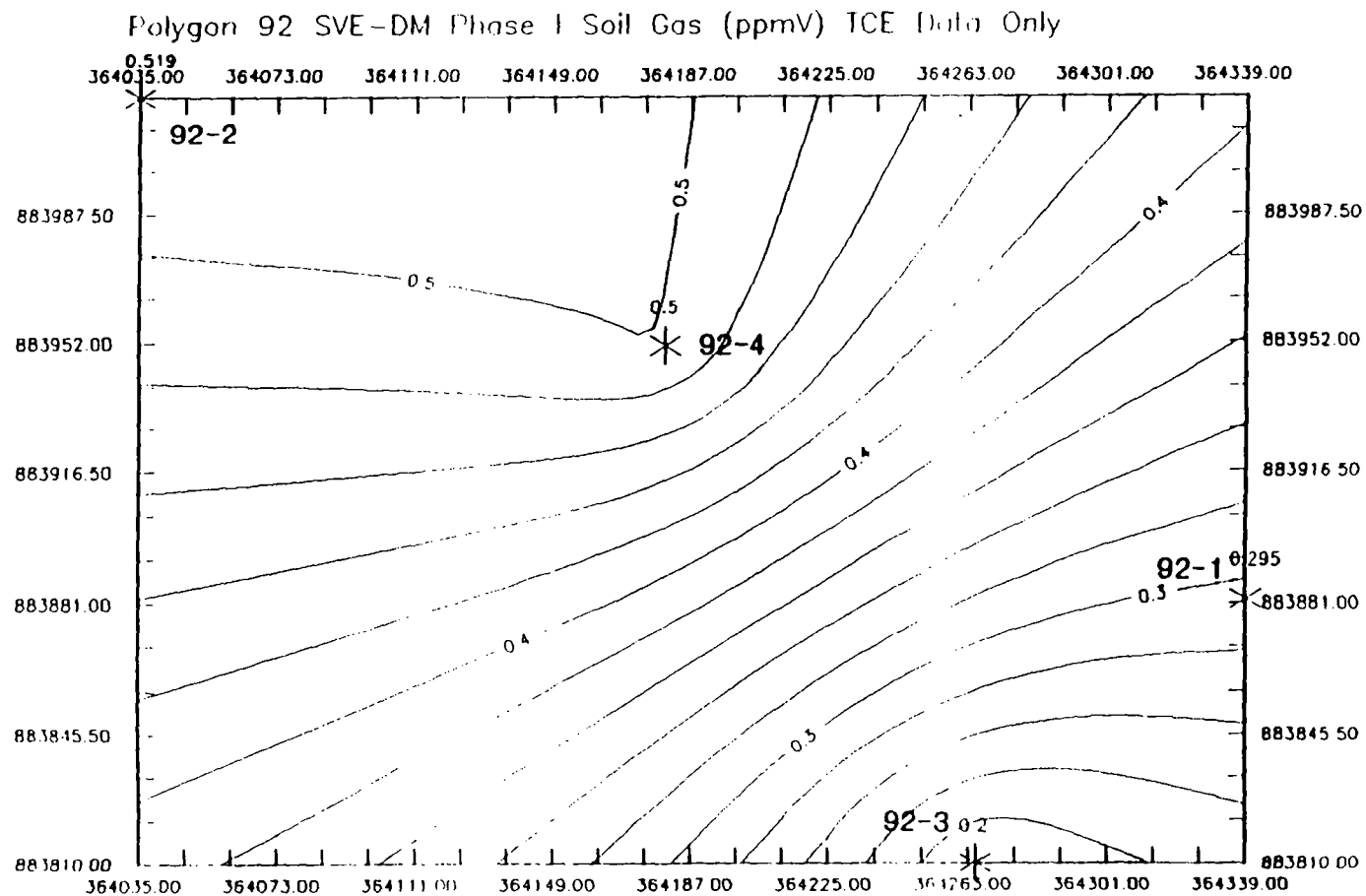
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2f



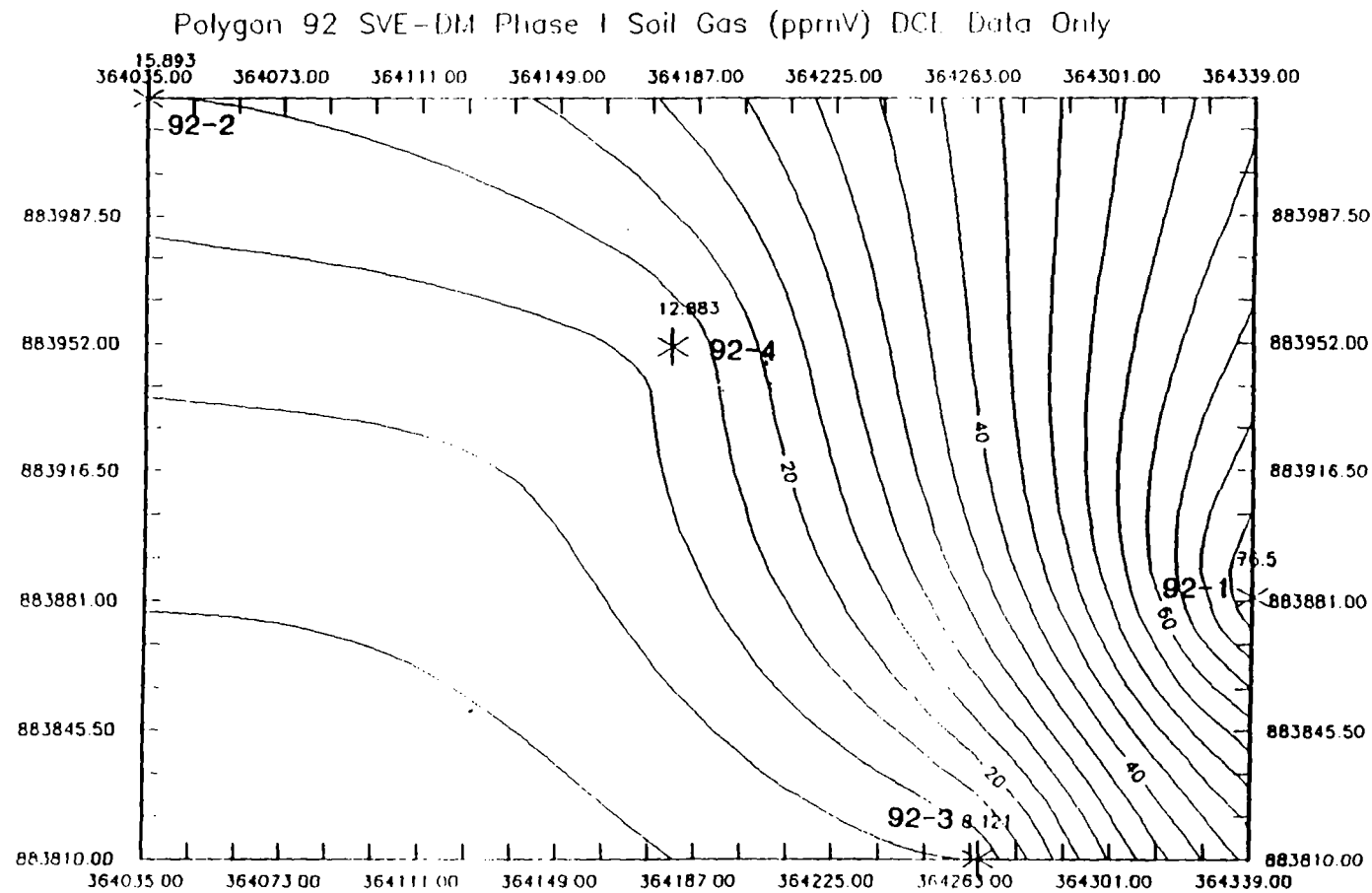
PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2g



PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2h



PHASE I CONTOURED PLOTS OF SOIL VAPOR SURVEY DATA

FIGURE 2-2I

and/or expected highest TCE soil vapor concentrations in each polygon as determined from results of the Phase I soil vapor probe survey. During drilling, soil core sampling at five (5) foot intervals was completed for three of four, Phase II borings including polygons 116, 117, and 79, while Polygon 92 was continuously core sampled for lithologic confirmation of the site's vadose zone lithologic layers (see Section 2.1.3.2). During drilling at selected depths, the occurrence of cobble layers in the subsurface at times prevented M&E from obtaining complete samples. In these instances, M&E successfully sampled immediately below the cobble layers at the first indication of the presence of cohesive soils (see Boring Logs in Appendix L). Selected soil samples (one per boring) were analyzed for VOC concentrations using full CLP laboratory protocol in order to establish baseline VOC concentrations for future evaluation of remedial progress and to facilitate site closure requirements.

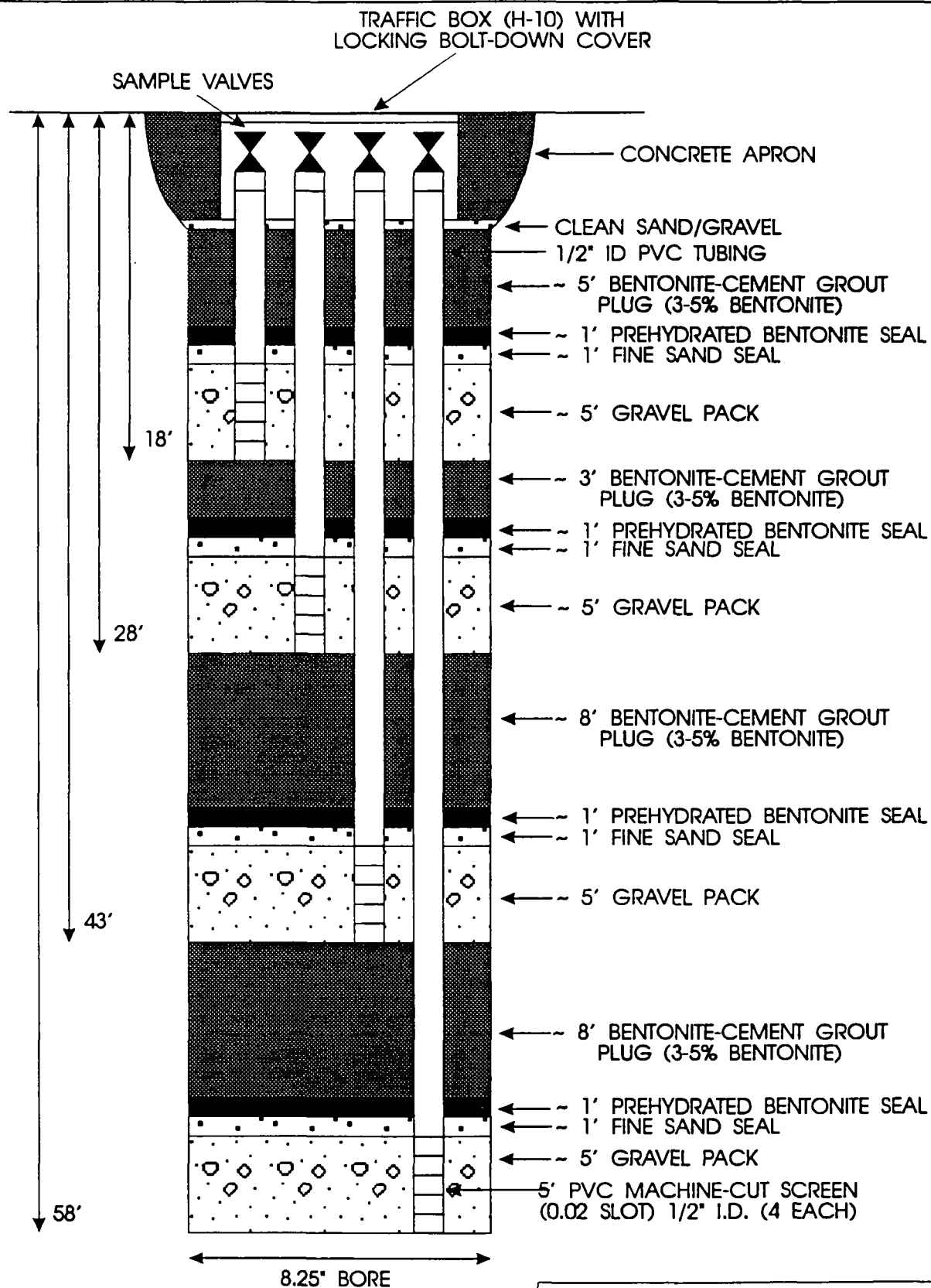
Personnel using the on-site laboratory equipment performed soil headspace VOC analyses of soil samples extracted every five feet below grade in order to determine relative vertical soil concentrations. This protocol was used to select the highest TCE contaminated soil interval sample to be analyzed by CLP protocol, and to assist in selecting appropriate soil vapor monitoring well screening intervals (Section 2.1.3.5 and Appendix B from the Design Memorandum). Selected soil samples (4 per boring) were also forwarded to a Certified geotechnical laboratory for a comprehensive physical testing schedule in order to evaluate the vadose zone soil physical properties (Section 2.1.3.4) and establish an average set of physical soil parameters to be used in the revised VLEACH and Mixing Cell modelling efforts. Two soil samples were submitted to the physical testing laboratory from the upper fine vadose zone and two samples were submitted from the lower coarse vadose zone. The four samples submitted to the laboratory roughly represent each 15-foot interval from ground surface to the water table and coincide with the four (4) depth-discrete soil vapor well screened intervals. The soil sample which most represented the average soil type within the given fifteen foot interval was selected for laboratory physical analysis.

Following the drilling and sampling of each Phase II boring, M&E converted each completed boring into a depth-specific vadose zone/soil vapor monitoring cluster well. The clustered well configuration consisted of four (4) individually completed vapor wells at specific depths within the

vadose zone so as to maximize vertical soil vapor monitoring coverage (see Figure 2-3 and Appendix L of this document for the well completion logs).

Following soil vapor monitoring well completion, M&E sampled each soil vapor monitoring well in each of the four polygons, and the collected samples were submitted to a U.S. EPA Contract laboratory for chemical analysis (Appendix J of this document). From the analytical results, M&E developed a vertically distributed profile of soil vapor VOC (as TCE) contamination in each of the four polygons to establish input to the refined VLEACH and Mixing Cell polygon screening. Figure 2-4 illustrates the soil vapor sample locations (equivalent to monitoring well screened intervals) and the derived vertical soil vapor distribution, for example Polygon 92. Determination of the TCE vertical distribution was achieved by first converting all soil vapor concentrations in units of $\mu\text{g/L}$ to total soil concentrations in units of $\mu\text{g/Kg}$ (on a dry bulk basis) using the series of equilibrium equations presented in Section 2.2.1.1 and as described further in Appendix I. As described in detail in Section 2.2.1.1, the total soil concentration ($\mu\text{g/Kg}$) data at specific depth intervals was linearly extrapolated to the midpoints of depths corresponding to individual VLEACH soil vertical intervals. These data were then extrapolated from the four polygons to all the Class 1 polygons directly contiguous to the four polygons investigated during the Phase II investigation (11 contiguous polygons, 15 polygons total). Table 2-2 presents the 79 Class I polygons that require VLEACH and Mixing Cell screening. The table characterizes the polygons as: the four investigated polygons; those polygons located contiguous to the investigated polygons (having a common border), which failed screen method #1 (Class 1); and all remaining Class 1 non-investigated, non-contiguous polygons. The models were run at one year interval time steps and printout increments over a thirty year timespan for each polygon.

Based on the results of this refined polygon screening, a determination was made as to whether the polygon in question required further investigation and/or SVE remediation (eg. whether Subunit A ground water, as determined by VLEACH and Mixing Cell, resulted in TCE concentrations in excess of $5 \mu\text{g/L}$ over a thirty year timeframe). The decision for investigation or remediation of polygons failing the refined VLEACH and Mixing Cell screening are and will be based on investigation data.



SCHEMATIC DIAGRAM OF
TYPICAL VACUUM MONITORING
CLUSTER CONSTRUCTION



Metcalf & Eddy

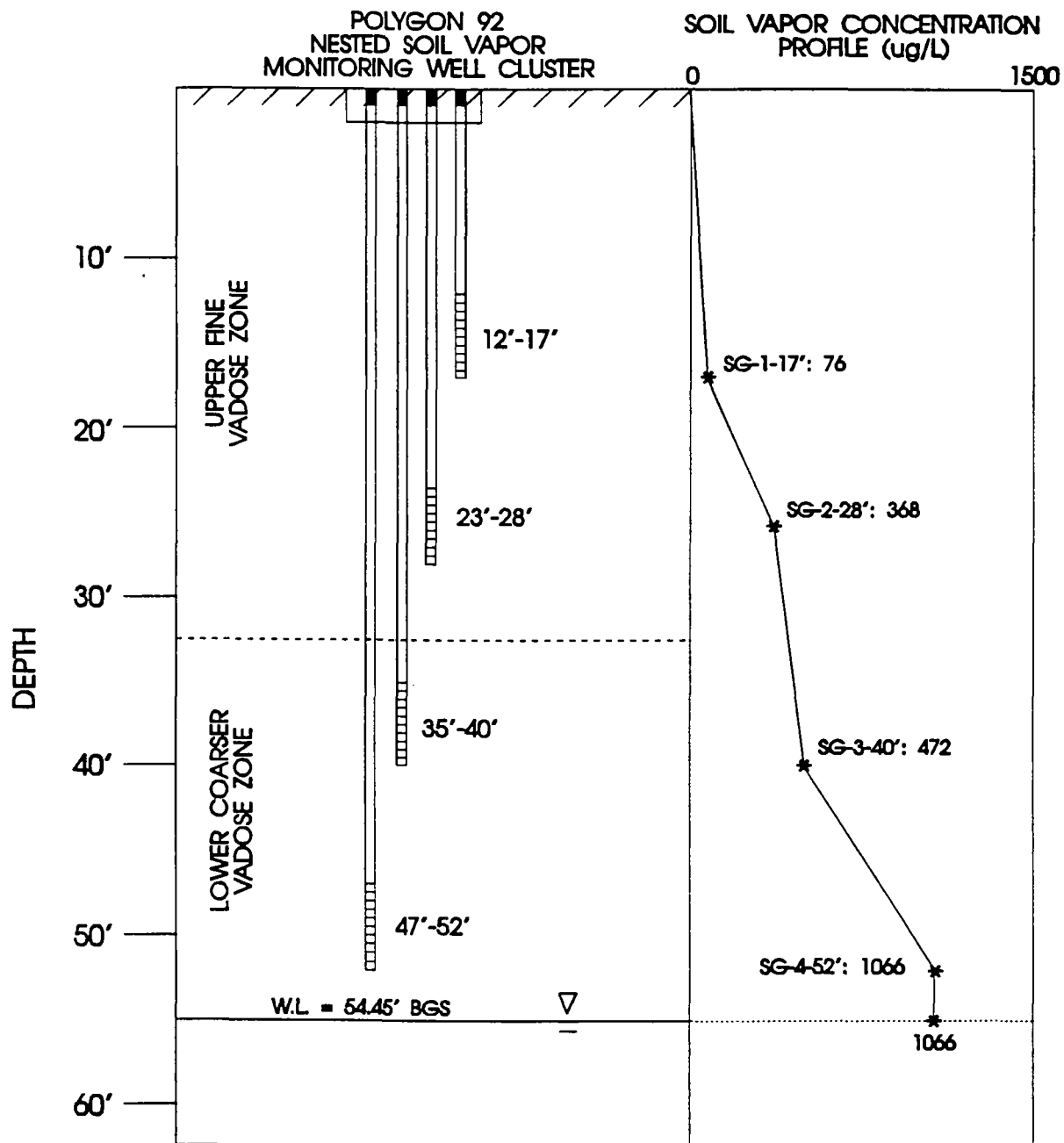
Drawn by:
J. Weldmann

Job
Number:
006791

Date:
September 1992

Checked by:
S. Zachary

Figure Number:
2-3



* SG-1-17': 76 = DEPTH-SPECIFIC SOIL GAS SAMPLE CONCENTRATION

POLYGON 92 SCHEMATIC OF SOIL
GAS CONTAMINANT VERTICAL
DISTRIBUTION IN VADOSE ZONE

M&E

Metcalf & Eddy

Drawn by:
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Job
Number:
006791

Date:
September 1992

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Figure Number:
2-4

TABLE 2-2

Summary of Phase I/II Investigated polygons, non-investigated contiguous polygons, and non-investigated, non-contiguous polygons

Phase I/II May 1992 Investigated Polygon (4 total)	Class 1 non-investigated Contiguous polygon (11 total) *	Class 1 non-investigated, non-contiguous polygon (64 total)
92	93 (92)	-
-	70 (92)	-
-	27A (92)	-
-	66 (92)	-
-	94 (92)	-
-	90, 37A (92)	-
-	28A (92)	-
79	153 (79)	-
-	82 (79)	-
116	114-115 (116)	-
117	103 (117)	-
-	-	65
-	-	113
-	-	96
-	-	87
-	-	41-43
-	-	14A
-	-	111
-	-	36
-	-	13A
-	-	88
-	-	24A
-	-	69
-	-	84
-	-	15A
-	-	32A
-	-	68
-	-	23A
-	-	21A ; 26A
-	-	98
-	-	64
-	-	151
-	-	11A
-	-	38
-	-	26-29; 32-35
-	-	51

* Polygons listed in this column are Class 1 contiguous polygons that were determined to fail screening test #1. All other Class 0 contiguous polygons have been omitted.

TABLE 2-2 (continued)

Summary of Phase I/II Investigated polygons, non-investigated contiguous polygons, and non-investigated, non-contiguous polygons

Phase I/II May 1992 Investigated Polygon (4 total)	Class 1 non-investigated Contiguous polygon (11 total)*	Class 1 non-investigated, non-contiguous polygon (64 total)
-	-	62
-	-	6A
-	-	2A
-	-	80
-	-	5A
-	-	67
-	-	63
-	-	59-61
-	-	99
-	-	50
-	-	74
-	-	22A
-	-	25A
-	-	39
-	-	3A
-	-	12A
-	-	31
-	-	16A
-	-	52
-	-	46
-	-	150
-	-	54
-	-	45
-	-	102
-	-	33A
-	-	49
-	-	40
-	-	76
-	-	95
-	-	101
-	-	17A
-	-	44
-	-	1A
-	-	97
-	-	25
-	-	30
-	-	55-57
-	-	103
-	-	58A; 38A

* Polygons listed in this column are Class 1 contiguous polygons that were determined to fail screening method #1. All other Class 0 contiguous polygons have been omitted.

Two of the four polygons which have been directly investigated using the methods described in this document were found to fail the VLEACH and Mixing Cell screening and require SVE Remedy (Polygons 79 and 92, see Section 2.2.2 and 2.2.3 for a full discussion). Those polygons failing the refined VLEACH and Mixing Cell screening that have not been investigated as outlined in this document will be prioritized for investigation and subsequent VLEACH and Mixing Cell screening (see Section 2.3). Investigated polygons passing the Refined VLEACH screening (Polygons 116 and 117) will not be considered for further investigation or SVE remedy as outlined in the 1990 Consent Decree (1990 Consent Decree, Appendix B).

2.1.3.1 Methodology

Phase II borings were advanced using the hollow stem auger method using a truck mounted drill rig. The hollow stem auger method demonstrated the ability to drill in indurated sediments containing boulders. Additionally, because continuous core sampling capabilities were required of the selected drill rig, the Central Mining Equipment (CME) Model 75HD rig was the selected candidate of choice, having high torque capabilities. The auger diameter used 8.25 inches O.D. which was sufficient to permit 3 inch diameter core sampling, and the capacity to drill through moderate cobble zones.

The subcontracted drilling crew was 40 hour-OSHA trained and certified, and demonstrated past experience drilling in the area of the PGA site. The drillers were held responsible for providing on-site grout mixing and auger decontamination capabilities. All drilling supplies were transported to the site by the rig and support vehicle prior to drilling activities. Section 6 of this Report contains the policy for Residuals Management of drilling cuttings and health and safety equipment.

2.1.3.2 Phase II Soil Sampling

Sampling during drilling included continuous core soil samples collected from ground surface to just above the ground water table using 2.5 foot long sleeves at Polygon 92. The collected 2.5 foot length core sleeves were lithologically logged using the Unified Soil Classification System,

appropriately labelled, and photographed by the site geologist. Continuous core sampling within Polygon 92 was designed to provide M&E with a complete lithologic profile of the entire vadose zone. Appendix L of this report contains the boring logs and well construction logs from the May, 1992 Phase I/II investigation.

In polygons 116, 117, and 79, soil samples were collected and logged from the soil borings at five foot intervals where possible, using a hammer driven, 24-inch length, 2-inch diameter, California-modified split-spoon sampler lined with pre-cleaned 2-inch diameter by 3-inch length brass liners (see field boring logs in Appendix L for a representation of Phase II soil sampling intervals). Liners from each 5-foot soil sampling interval collected were field screened and logged by a site geologist, and replicates were prepared for headspace analysis by the on-site mobile laboratory (Section 2.1.3.3). Each soil sample replicate was analyzed by the on-site laboratory gas chromatograph using the headspace method. Results of soil headspace VOC concentration were plotted as a function of depth for each of the Phase II borings. Results of the analyses provided M&E with a qualitative vertical profile of VOC concentrations from ground surface to the Subunit A ground water table for each Phase II boring. Soil headspace analytical results were used solely to adjust vertical positioning of soil vapor monitoring well screen intervals. Vertical profiling of soil headspace concentrations with depth is important as it relates to the PGA site since contaminants would be expected to migrate from the two distinct sources in the vadose zone:

1. surface soils resulting from surface spills and releases
2. the capillary fringe overlaying the ground water which would result from off-gassing of volatile compounds in contaminated ground water.

By vertically profiling soil concentrations, M&E was able to qualitatively identify and isolate areas of higher contamination and target these areas for VLEACH and Mixing Cell modelling and subsequent soil vapor monitoring and SVE remedy if required.

Replicate samples for potential off-site physical and/or chemical testing (Section 2.1.3.3 and 2.1.3.4) were immediately labelled and sealed by placing Teflon liners over the exposed ends, secured in place by tight fitting plastic end caps, and placed in coolers at 4° Centigrade.

Table 2-3 summarizes the total number and type of chemical sampling and analysis completed for the Phase I and Phase II efforts of this investigation.

2.1.3.3 Chemical Soil Sample Analysis

SPOP

To ensure that the highest concentrations within a soil interval were identified, soil headspace analyses were conducted. The soil headspace analyses were performed in the field laboratory using a GC on soils sampled approximately every five feet in each of the four Phase II borings. Soil ring or core samples were initially field screened using a hand held photoionization detector instrument and the reading recorded for each interval on a field boring log (see Appendix L). A 50 gram subsample from each depth interval was then quickly transferred into a pre-weighed, labelled septum lined, 8-ounce capacity, pre-cleaned soil jar using a decontaminated stainless steel spatula to avoid volatile losses from the sample to the atmosphere.

Gaseous standards at three known concentrations containing TCE, PCE, 1,1-DCE, and 1,1,1-TCA were routinely injected into the GC at regular intervals in order to maintain instrument calibration over the course of the May, 1992 investigation. Full QA/QC protocol for the field laboratory soil headspace screening is presented in Appendix H of the May, 1992 SVE Design Memorandum. Soil headspace analytical results were not used in the development of the vertical contaminant distribution input for VLEACH and Mixing Cell screening, but did provide M&E with the means to both evaluate the vertical distribution and magnitude of VOC contamination in the vadose zone, and to target the high soil VOC concentrations zones for the placement of the clustered soil vapor monitoring well screens. A duplicate of the soil sample demonstrating the highest head-space concentration for each Phase II boring was submitted to the CLP-approved laboratory for TCL analysis via EPA Method 8240.

TABLE 2-3

**SOIL AND SOIL VAPOR SAMPLING RECORD FOR PHASE I
AND Phase II INVESTIGATION ACTIVITIES - CLASS 2 POLYGONS**

Parameter Phase #	Analytical Method	Shallow Soil Vapor	Soil Vapor (Depth Specific)	Soil Core*	Trip Blanks	Equipment Blanks	Duplicates
IND VOC's Phase I	On-site GC	16	NA	NA	NA	2	10% (2)
IND VOC's Phase II	Soil Headspace On-site GC U.S. EPA 3810	NA	NA	48	NA	Daily (30)***	10% (5)
TCL VOC's	U.S. EPA 8240 (CLP)	NA	NA	4	NA	4	10% (1)
TCL VOC's Phase II	U.S. EPA TO-14	NA	16	NA	NA	10% (2)	10% (2)

* Denotes continuous core and split-spoon soil samples.

TCL Target Compound List

On-site Analysis conducted by on-site mobile laboratory

CLP Analysis conducted by CLP laboratory (off-site)

NA Not Applicable

IND Denotes site indicator compounds (TCE, PCE, 1,1-DCE, 1,1,1-TCA)

The selected duplicate soil samples (one per boring) collected during boring activities corresponding to the greatest headspace VOC concentration detected in the field laboratory were submitted to a CLP-approved laboratory for QA/QC Level 4 analyses using EPA Method 8240. Results from the CLP soil sample analyses were originally intended to be used to establish a baseline soil VOC concentration for future evaluation of remedial progress and to facilitate site closure requirements. However, CLP analytical results detected none of the four targeted compounds (TCE, PCE, 1,1-DCE, and 1,1,1-TCA) in the four soil samples submitted for analysis. Laboratory reports for these analyses are presented in Appendix J.

2.1.3.4 Physical Soil Sample Analysis

Selected soil core samples were forwarded to a certified Geotechnical laboratory for physical testing. A total of sixteen (16) soil samples were submitted to the laboratory for physical analysis from the four Phase II borings. Four soil samples were selected from each Phase II polygon boring; two from within the upper fine vadose zone (ground surface to approximately 25-30 feet below ground surface (bgs), and two samples from the lower coarse vadose zone (30 feet bgs to the capillary fringe or approximately 60 feet bgs). The selection of appropriate vertical intervals was based on the following rationale: the vadose zone was conceptually divided into four cells roughly equalling 15-foot depths from ground surface to the water table. Soil samples collected from each 15-foot interval in each boring were positioned adjacent to one another in the field laboratory. That sample which was considered most representative of the average physical soil type from each 15-foot depth interval was selected for physical analysis. Since a total of four "cells" comprise each boring, four "representative" samples were submitted for analysis from each boring. The four samples from each boring also roughly coincided with the screen intervals of the depth-discrete soil vapor wells.

The scheduled physical soil testing for selected samples included bulk dry density, native water content, particle size distribution, hydraulic conductivity, air permeability at the native water content, and total organic carbon content. Initially, the laboratory measured total organic matter content of the submitted samples. After this was discovered, in consultation with the U.S. EPA, the laboratory was instructed to rerun unused portions of the identical samples for total organic carbon content using

the Walkley-Black Method. A summary of the physical testing results and corresponding testing methods is presented in Table 2-4. Field tensiometry measurements were not performed in the field due to the high ambient air temperature and low air humidity conditions. Subsamples of soil cores were prepared, labelled, handled, and managed on-site under the direction of the Quality Assurance Officer (see Appendix B of the May, 1992 Design Memorandum). This suite of physical analyses listed in Table 2-4 is considered to be comprehensive and provides the necessary data with which to conduct the refined VLEACH and Mixing Cell modeling and finalize implementation of the SVE operable unit remedy design phase of this report.

The laboratory physical results were averaged to arrive at a single set of representative site physical soil physical parameters. The averaging technique used was a simple arithmetic mean which involved summing the four values from each of the four borings, and dividing by the number of samples (16). This simple technique has the ability to naturally weight the averaged value in favor of the most dominant soil physical parameters characterizing the PGA site vadose zone. Results of the physical soil analyses resulted in the following averaged parameters: bulk dry density, 1.64g/cm³, native volumetric water content, 25.5% and total organic carbon content, 0.074% by weight (see Table 2-4). The results of the soil physical testing and averaging comprise a single set of soil physical parameters for the entire PGA site vadose zone. Following U.S. EPA approval of the finalized physical soil site vadose zone parameters, the revised parameters were entered into the VLEACH and Mixing Cell models and 32 of the Class 1/Class 2 polygons were re-screened and prioritized to determine the potential threat to the Subunit A ground water.

In addition to the analyses presented in Table 2-4, M&E determined the total porosity and air-filled porosity of the submitted samples using the following relationships. The total porosity of a soil is related to the bulk dry density, ρ_b , according to the following equation:

$$n = 1 - \rho_b / \rho_s \quad (\text{Freeze \& Cherry, 1979})$$

TABLE 2-4
SUMMARY OF SVE PHASE II PHYSICAL SOIL TESTING RESULTS
AND LABORATORY METHODS, JULY 1992

SAMPLE DESIGNATION	BULK DENSITY ASTM D2937 pcf*	BULK DENSITY ASTM D2937 g/cc	CALCULATED TOTAL POROSITY** %	MOISTURE CONTENT ASTM D2216 Wt %	MOISTURE CONTENT ASTM D2216 Vol %	CALCULATED AIR-FILLED POROSITY*** %	ORGANIC MATTER ASTM D2974 Wt. %	ORGANIC CARBON WALKLEY-BLACK Wt. %	HYDRAULIC CONDUCTIVITY EPA Method 9100 cm/sec	AIR CONDUCTIVITY API Modified RP-40 cm/sec
POLYGON 92										
PS-92-14	111.5	1.79	32.6	11.00	19.69	12.91	1.5	0.05	1.8E-07	1.00E-04
PS-92-24	94.5	1.51	42.9	19	28.69	14.21	12.1	0.15	7.3E-05	1.40E-07
PS-92-39	100.5	1.61	39.3	27	43.47	-4.17	3.1	0.04	3.4E-07	3.70E-04
PS-92-44	105	1.68	36.5	19	31.92	4.58	1.2	0.02	6.4E-05	2.80E-05
POLYGON 79										
PS-79-11	102	1.63	38.5	9	14.67	23.83	5.7	0.03	4.6E-06	3.80E-04
PS-79-25.5	93	1.49	43.8	21	31.29	12.51	1.9	0.08	1.9E-08	1.80E-08
PS-79-35	104.5	1.67	37	9	15.03	21.97	0.4	0.09	1.1E-04	1.30E-06
PS-79-44	101	1.62	38.9	7	11.34	27.56	1	0.13	5.0E-04	6.60E-04
POLYGON 116										
PS-116-15	84	1.35	49.1	31	41.85	7.25	6.4	0.02	6.4E-07	1.00E-06
PS-116-25.5	91	1.47	44.6	27	39.69	4.91	2.2	0.07	5.0E-07	3.00E-07
PS-116-35.5	117	1.87	29.3	6	11.22	18.08	1.3	0.05	2.1E-06	4.90E-04
PS-116-50	119	1.91	27.9	5	9.55	18.35	1.1	0.13	3.6E-03	9.40E-04
POLYGON 117										
PS-117-14.5	97.6	1.56	41.1	23	35.88	5.22	2.5	0.06	2.4E-08	3.20E-05
PS-117-28.5	100.5	1.61	39.3	13.6	21.90	17.40	0.9	0.15	4.3E-05	9.30E-04
PS-117-37.5	102	1.63	38.5	13.5	22.01	16.49	1.7	0.02	1.5E-04	5.30E-08
PS-117-55	116	1.86	29.8	7.5	13.95	15.85	1	0.09	1.2E-04	1.00E-03
SUM	1639.10	26.26	609.10	248.60	392.15	216.95	44.00	1.18	4.7E-03	4.9E-03
AVERAGE	102.44	1.64	38.1	15.54	25.49	12.61	2.75%	0.074 %	2.9E-04	3.1E-04

* CONVERSION: (pcf)/(62.4) = (g/cc)

** CALCULATION: (porosity) = 1 - (bulk density(g/cc)/particle density(g/cc))
assume particle density equals 2.65 g/cc

*** CALCULATION: (total porosity) - (vol. water content) = (air-filled porosity)

Where:

n = porosity (dimensionless)

ρ_b = bulk dry density (g/cm³)

ρ_s = particle density (g/cm³)

Assuming a particle density of 2.65 g/cm³ (valid for most all mineral soils), determination of the bulk density permitted the direct calculation of the porosity of the soils investigated. Having determined both the native water content, and the calculated porosity, the air-filled porosity of the soils was determined using the following equation:

$$n = \theta_t = \theta_a + \theta_w$$

Where:

n = total porosity = θ_t

θ_a = air-filled porosity

θ_w = volumetric water content

The air-filled porosity parameter, θ_a , expresses the percentage of air-filled pores with which to transmit soil vapors during advective and diffusive contaminant transport as well as during operation of a vapor extraction system. Based on these equations, the following porosities were calculated: total porosity (θ_t), 38.1%; air filled porosity (θ_a), 12.6%; and volumetric water content (θ_w), 25.5%.

Comprehensive grain size distribution analyses were also performed to provide a means to assess the influence of soil texture on vapor transport. Grain size distribution results for the sixteen submitted samples are presented as grain size distribution curves in Appendix J. Results of the grain size analyses reveal that the top 30 to 35 feet of the vadose zone are characterized by fine sands, silts, and clays. The lower 25 to 30 feet of the vadose zone is characterized by moderately to poorly sorted medium to coarse sands and gravels. However, discontinuous silt and silty clay layers were also observed at a depth of approximately 38 feet in Polygon 92 reflecting the alluvial influence of the depositional environments. Also, hydraulic conductivity tests were performed on the soils

submitted to the laboratory. Hydraulic conductivity describes the rate of fluid flow through porous media under applied pressure gradients. These data as well as laboratory air permeability testing results were directly used for vadose zone characterization during the design phase of the Soil Vapor Extraction System (Section 3). Results of the hydraulic and air conductivity testing reveals that the lower 25 to 30 feet of vadose zone is very conducive to vapor transport and SVE remedy. The upper 30 to 35 feet of vadose zone soils are less permeable, thus requiring additional effort for SVE remedy with respect to applied vacuums to overcome the diffusion-limited process of contaminant volatilization in the fine soils.

All physical test results were performed according to accepted standard methods, averaged as described above, and incorporated into the refined VLEACH and Mixing Cell data base for polygon screening.

2.1.3.5 Soil Vapor Monitoring Well Construction

Soil vapor monitoring well construction immediately followed the drilling and sampling of the Phase II borings. Four monitoring wells, constructed in a nested fashion such that each of the four wells are installed independently of one another, were completed at each Phase II boring locations. Each well was installed with one half (1/2)-inch diameter, Schedule 40 PVC casing, slotted with a five foot length screened interval at the base with blank casing extending upwards to just below ground surface. Refer to Figure 2-3 for a typical completed soil vapor monitoring well cluster installation. The construction using five foot screened lengths was selected to maximize the total screened depth of vadose zone soil vapor monitoring in each Phase II boring. Using this construction, a total of twenty feet of screen is open to soil vapor sampling which is over 30% coverage of the entire vadose zone. The screened intervals proposed were as follows: 13-18 feet, 23-28 feet, 38-43 feet, and 53-58 feet below ground surface. In the field, however, subsurface conditions and soil headspace analytical results mandated a slightly different set of screening intervals in each of the four investigated polygons (see well construction diagrams in Appendix L). The rationale for using these approximate screened intervals is to characterize the upper fine vadose zone soils (13-18 feet), the approximate interface between the upper fine and lower coarse vadose zone

soils (23-28 feet), and to characterize the lower coarse soils and the capillary fringe (38-43 feet, and 53-58 feet, respectively). The soil headspace analytical results were used in conjunction with field observations gathered during Phase II boring activities in order to fine tune and slightly modify the screened interval schedule. Screened intervals were adjusted in the field based on soil headspace analyses from the on-site laboratory to intersect the most contaminated soils within the stated zone. In all cases, the screened section of any given well was not moved any more than 3 feet in any direction.

The monitoring wells were constructed in the order of greatest depth first, proceeding upwards until the shallowest well installation was completed. A gravel pack of 8-12 sieve silica sand was installed around the screened interval, with a #30 sieve silica sand seal extending to approximately one half foot above and below each screened interval to prevent the bentonite seal from intruding through the gravel and sealing off the well screen. Above the sand seal, a minimum one-foot thick pre-hydrated bentonite seal was constructed to seal each well from the influence of other wells constructed within the borehole. The bentonite seal was constructed in 6-inch lifts and carefully hydrated with deionized water to ensure that the entire bentonite lift was hydrated; but reduce the risk of disturbing the vadose zone contaminant equilibria and mobilizing the contaminants. Above each bentonite seal, a 3 to 5 percent bentonite-cement grout mixture was tremied into place to a depth corresponding to the bottom of the next screening interval. A preliminary laboratory test was performed prior to drilling activities in order to evaluate the sealing efficiencies of different batch mixtures of bentonite cement. The conclusion of this study demonstrated that a 5% mixture provided a superior vacuum tight seal around a 1/2-inch diameter segment of the PVC pipe. Accordingly, this 5% mixture was carefully measured and administered as a sealing medium in each of the individual vapor monitoring wells. After an adequate curing time was allowed for each installation, the construction process was repeated until the shallowest well had been installed. Above the shallowest well, a 5% bentonite-cement mixture was tremied to a depth of 3 feet below grade.

To complete each nested well installation, a 3-foot deep, 2.5 foot square pilot hole was excavated into which a one-foot thick layer of sand/gravel was placed. A locking steel monument box was positioned into the excavated hole and secured in place with a concrete envelope to complete the

construction of each well (see Drawing M-1, Detail 4). Each well was labelled by a unique designation indicating its location, total depth, and screened depth interval. A well construction diagram was completed for each nested construction (See Appendix L).

2.1.3.6 Soil Vapor Monitoring Well Sampling

Following completion of the cluster wells in each of the four polygons, M&E purged and sampled each well of soil vapor for submission to a Certified laboratory for chemical analysis using EPA Method TO-14. As stated in the May, 1992 Design Memorandum during the Phase II activities, M&E allowed a minimum of five working days to elapse following each well completion prior to sampling in order to allow the bentonite, grout, and cement to cure. Following this minimum time period, M&E purged and sampled each well according to the QA/QC protocol described in the following paragraphs and in Appendix C of the May, 1992 Design Memorandum.

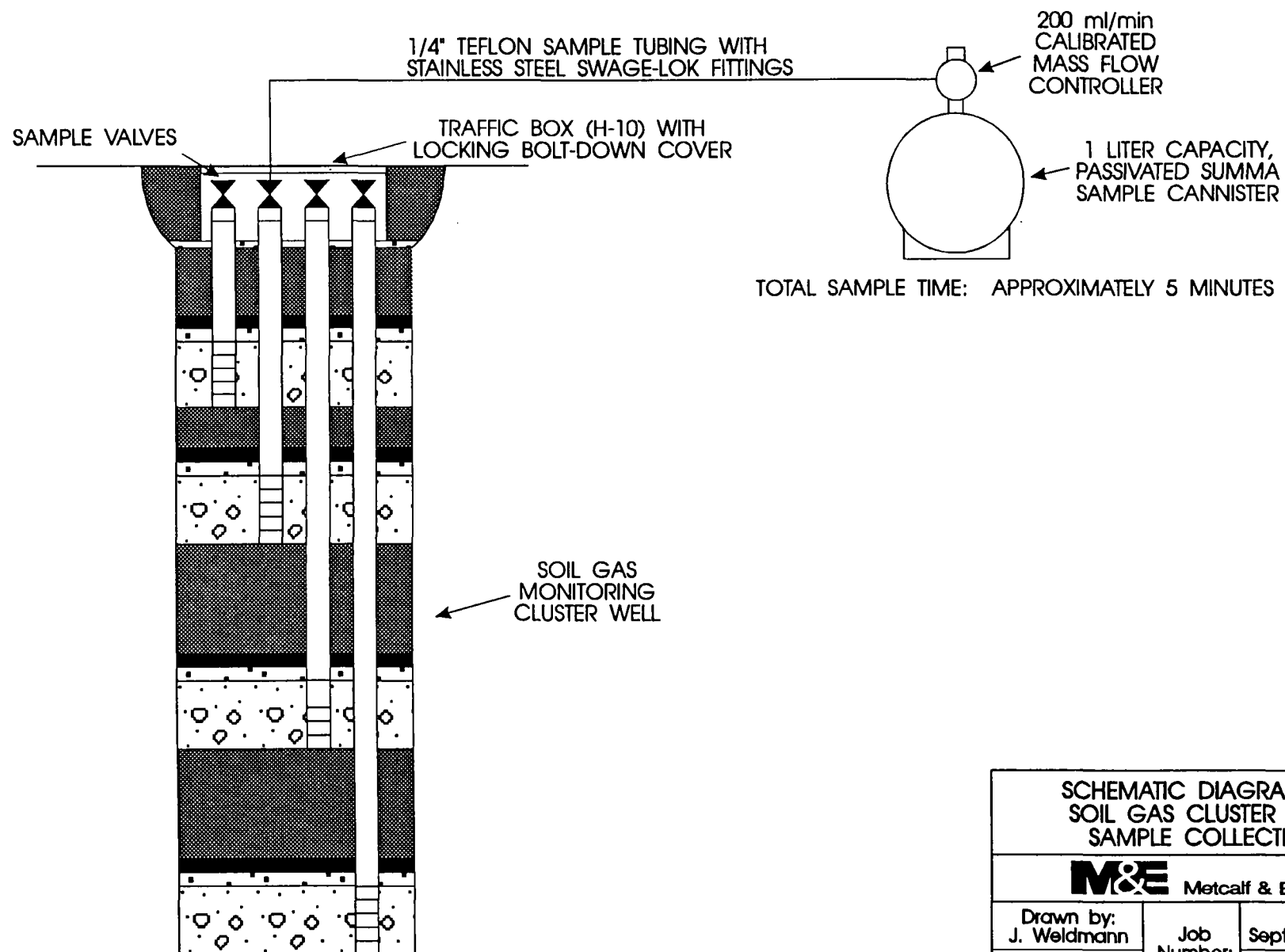
Each well was initially purged of a maximum of two (2) well volumes of vapor or until a peak of VOC concentrations occurred, whichever came first. This was achieved by connecting a diaphragm pump to the well header, and allowing it to pump for a time period calculated by dividing the product of two times each well volume capacity, by the pump rate determined during pumping. The result of this relationship yielded the total pumping time required to purge two well volumes for each individual well purged. The purge rate was controlled by a computer-controlled mass flow controller. Pump volumes were controlled and input into the computer and pumping times were measured using a stopwatch accurate to a least one-tenth of a second. The proposed two-well volume initial purge was considered to be sufficient to completely evacuate the well, and to initiate soil vapor flow into the well screen. The well purging procedure was necessary to obtain "representative" native soil vapor in the immediate vicinity of the well screen without introducing problems of source depletion arising from overpurging. In actuality, an average of 1.7 well purge volumes as opposed to 2.0 well volumes was found to give rise to maximum soil vapor concentrations. VOC concentrations were monitored continuously during purging with a photoionization detector positioned at the exhaust of the purge pump. Following purging, the pump was deactivated and each well was allowed to equilibrate to ambient pressure and remain static for

a time period of at least ten minutes to allow time for VOC migration into the previously evacuated soil pores. During this time of equilibration, the well and sampling trace was closed to atmospheric air to prevent sample dilution.

Following purging, each well was prepared for soil vapor sampling. Initially, a stainless steel gas-tight fitting was installed at each soil vapor wellhead. A new segment of one quarter (1/4)-inch diameter Teflon (PTFE) tubing was attached to the wellhead fitting. A stainless steel passivated SUMMA canister equipped with a pre-cleaned mass flow controller calibrated to 200 ml/min was connected to the downstream segment of Teflon tubing. Prior to sampling, the system was leak checked using a soap solution. All plumbing connections were found to be vacuum tight during the Phase II soil vapor sampling.

To initiate sample collection, a needle valve positioned between the SUMMA canister and the mass flow controller was opened where the vacuum within the canister provided the driving force necessary for sample collection. Sampling time was set at 5 minutes, resulting in a soil vapor sample volume of approximately 1.2 liters (Figure 2-5). Duplicate samples as indicated in Table 2-3 were collected by using a second SUMMA canister and the identical sampling methodology.

The January, 1992 SVE Design Memorandum proposed using carbon tubes for sampling vapors with the objective of accurately determining low detection limits. The field data demonstrated VOC concentrations in the ppmV range which provided for minimal calculated volumes of gas sample to pass through the carbon tubes prior to breakthrough. The accuracy gained by the use of carbon tubes is from the ability to pass a large volume of low concentration air through the tube. This advantage was lost because of the minimal volume of gas sample required to be collected (without breakthrough). To resolve the issue, whole air samples were collected and analyzed using SUMMA canisters. This change was discussed with U.S. EPA and approved prior to implementing the change in the field. The change in the field sampling protocol was included in the Revised SVE Design Memorandum and associated Quality Assurance Project Plan (May, 1992).



SCHEMATIC DIAGRAM OF
SOIL GAS CLUSTER WELL
SAMPLE COLLECTION



Metcalf & Eddy

Drawn by:
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Job
Number:
006791

Date:
September 1992

Checked by:
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Figure Number:
2-5

All collected Phase II soil vapor monitoring well samples were appropriately labelled and stored prior to transport to a Certified laboratory for chemical analysis of the targeted compounds listed in Table 2-5 using EPA method TO-14. See Appendix C of the May, 1992 Design Memorandum for QA/QC protocol. Appendix J of this report contains the results of the soil vapor chemical analyses.

TABLE 2-5	
U.S. EPA METHOD 8240.	
TCL LISTING OF SCREENED ANALYTES	
DETECTION LIMIT IN SOIL VAPOR: 0.01 Mg/L	
Benzene Carbon tetrachloride Chlorobenzene Chloroform 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene Methylene chloride	Tetrachloroethene Toluene Trichloroethene (TCE) 1,1,1-Trichloroethane Vinyl chloride Total Xylenes
.Soil vapor analyzed under U.S. EPA Method TO-14 and specified for the above compounds as a subset of the U.S. EPA Method 8240 compound list.	

A summary of the Phase II laboratory analytical results of samples collected from the soil vapor monitoring cluster wells for the four investigated polygons is presented in Table 2-6. It should be noted that sample VS-VP92-47 is a field duplicate of sample VS-VP92-52. In cases where duplicate sample analyses are run, the higher of the two values was entered into VLEACH input files. Referring to the Table 2-6 laboratory analytical results, several interesting trends regarding contaminant type and distribution for the four investigated polygons are noted. Polygon 92 analytical results indicate a distinct "bottom loaded" VOC trend where total VOC concentrations show a progressive increase with depth (lower coarse soils), with 1,1-DCE as opposed to TCE being the predominant (over an order of magnitude) contaminant type.

TABLE 2-6

SUMMARY OF PHASE 2 VERTICAL SOIL VAPOR MONITORING WELL LABORATORY ANALYTICAL RESULTS

Sample Designation	Compounds	MDL (ppbv)	MDL (ug/L)	Concentration (ppbv)	Concentration (ug/L)
VS-VP92-17	Trichloroethene	470	2.8	4300	23
	Tetrachloroethene	470	3.1	530	3.5
	1,1- Dichloroethene	470	1.8	30000	116
	1,1,1- Trichloroethane	470	2.5	96	0.51
VS-VP92-28	Trichloroethene	980	5.2	20000	110
	Tetrachloroethene	980	6.5	2600	17
	1,1- Dichloroethene	980	3.8	140000	540
	1,1,1- Trichloroethane	980	5.2	4800	26
VS-VP92-40	Trichloroethene	2300	12	22000	120
	Tetrachloroethene	2300	16	3100	21
	1,1- Dichloroethene	2300	8.9	160000	620
	1,1,1- Trichloroethane	2300	12	14000	75
VS-VP92-40LD	Trichloroethene	2300	12	21000	110
	Tetrachloroethene	2300	16	3300	22
	1,1- Dichloroethene	2300	8.9	170000	680
	1,1,1- Trichloroethane	2300	12	16000	85
VS-VP92-47	Trichloroethene	4700	25	7400	39
	Tetrachloroethene	4700	31	2400	16
	1,1- Dichloroethene	4700	18	270000	1100
	1,1,1- Trichloroethane	4700	25	160000	850
VS-VP92-52	Trichloroethene	570	3	1000	5.3
	Tetrachloroethene	570	3.8	320	2.1
	1,1- Dichloroethene	570	2.2	35000	140
	1,1,1- Trichloroethane	570	3	21000	110
ND - Not Detected NA - Not Available MDL - Method Detection Limit					
D - Duplicate LD - Laboratory Duplicate					

TABLE 2-6 (continued)

**SUMMARY OF PHASE 2 VERTICAL SOIL VAPOR
MONITORING WELL LABORATORY ANALYTICAL RESULTS**

Sample Designation	Compounds	MDL (ppbv)	MDL (ug/L)	Concentration (ppbv)	Concentration (ug/L)
VS-VP79-16	Trichloroethene	120	0.63	10000	53
	Tetrachloroethene	120	0.8	95	0.63
	1,1- Dichloroethene	120	0.47	380	1.5
	1,1,1- Trichloroethane	120	0.64	NA	NA
VSVP79-28	Trichloroethene	2500	9.2	54000	280
	Tetrachloroethene	2500	16.6	340	2.3
	1,1- Dichloroethene	2500	9.7	2100	8.1
	1,1,1- Trichloroethane	2500	13	NA	NA
VS-VP79-40	Trichloroethene	2400	13	180000	950
	Tetrachloroethene	2400	16	850	5.6
	1,1- Dichloroethene	2400	9.3	2300	8.9
	1,1,1- Trichloroethane	2400	13	NA	NA
VS-VP79-51	Trichloroethene	4900	26	490000	2600
	Tetrachloroethene	4900	33	2000	13
	1,1- Dichloroethene	4900	19	9200	36
	1,1,1- Trichloroethane	4900	26	NA	NA
ND - Not Detected NA - Not Available MDL - Method Detection Limit					

D - Duplicate

SUMMARY OF PHASE 2 VERTICAL SOIL VAPOR MONITORING WELL LABORATORY ANALYTICAL RESULTS

Sample Designation	Compounds	MDL (ppbv)	MDL (ug/L)	Concentration (ppbv)	Concentration (ug/L)
VS-VP-116-16	Trichloroethene	9.4	0.049	5.1	0.027
	Tetrachloroethene	9.4	0.062	22	0.16
	1,1- Dichloroethene	9.4	0.035	ND	ND
	1,1,1- Trichloroethane	9.4	0.05	ND	ND
VS-VP116-27	Trichloroethene	17	0.067	30	0.16
	Tetrachloroethene	17	0.11	21	0.14
	1,1- Dichloroethene	17	0.066	ND	ND
	1,1,1- Trichloroethane	17	0.091	NA	NA
VS-VP116-28	Trichloroethene	9	0.047	54	0.28
	Tetrachloroethene	9	0.06	33	0.22
	1,1- Dichloroethene	9	0.035	ND	ND
	1,1,1- Trichloroethane	9	0.048	ND	ND
VS-VP116-28LD	Trichloroethene	12	0.063	55	0.29
	Tetrachloroethene	12	0.08	36	0.24
	1,1- Dichloroethene	12	0.047	ND	ND
	1,1,1- Trichloroethane	12	0.064	ND	ND
VS-VP116-41	Trichloroethene	9.4	0.049	760	4
	Tetrachloroethene	9.4	0.062	9.4	0.062
	1,1- Dichloroethene	9.4	0.036	ND	ND
	1,1,1- Trichloroethane	9.4	0.05	20	0.11
VS-VP116-53	Trichloroethene	9.4	0.049	1300	6.8
	Tetrachloroethene	9.4	0.062	4.4	0.029
	1,1- Dichloroethene	9.4	0.036	3.4	0.013
	1,1,1- Trichloroethane	9.4	0.05	200	1.1
ND - Not Detected NA - Not Available MDL - Method Detection Limit D - Duplicate LD - Laboratory Duplicate					

TABLE 2-6 (continued)

**SUMMARY OF PHASE 2 VERTICAL SOIL VAPOR
MONITORING WELL LABORATORY ANALYTICAL RESULTS**

Sample Designation	Compounds	MDL (ppbv)	MDL (ug/L)	Concentration (ppbv)	Concentration (ug/L)
VS-VP117-16	Trichloroethene	4.5	0.024	ND	ND
	Tetrachloroethene	4.5	0.03	6.9	0.045
	1,1- Dichloroethene	4.5	0.017	ND	ND
	1,1,1- Trichloroethane	4.5	0.024	53	0.28
VS-VP117-30	Trichloroethene	24	0.13	ND	ND
	Tetrachloroethene	24	0.16	22	0.15
	1,1- Dichloroethene	24	0.093	ND	ND
	1,1,1- Trichloroethane	24	0.13	67	0.36
VS-VP117-44	Trichloroethene	1200	6.3	ND	ND
	Tetrachloroethene	1200	8	ND	ND
	1,1- Dichloroethene	1200	4.7	ND	ND
	1,1,1- Trichloroethane	1200	6.4	ND	ND
VS-VP117-55	Trichloroethene	2400	13	ND	ND
	Tetrachloroethene	2400	16	ND	ND
	1,1- Dichloroethene	2400	9.3	ND	ND
	1,1,1- Trichloroethane	2400	13	ND	ND
ND - Not Detected NA - Not Available MDL - Method Detection Limit					
D - Duplicate					

Analytical results for Phase II soil vapor samples collected from Polygon 79 also indicated a progressive increase in VOC concentrations with depth and thus a bottom loaded vertical distribution. However, the compound TCE was consistently detected at one to two orders of magnitude greater concentration than 1,1-DCE, 1,1,1-TCA, and PCE. Polygon 79 contained the greatest concentrations of TCE in soil vapor than the other three investigated polygons.

Polygon 116 analytical soil vapor results similarly indicated a bottom loaded vertical distribution with TCE as the principal contaminant. Concentrations of VOCs in Polygon 116 at all four depths are limited to less than 7 $\mu\text{g/L}$ whereas concentrations of VOCs in Polygons 79 and 92 were detected on the order of hundreds to thousands of $\mu\text{g/L}$ VOCs.

Polygon 117 soil vapor analytical results indicated the detected presence of the compounds PCE and 1,1,1-TCA at concentrations of less than 1 $\mu\text{g/L}$. Detectable concentrations of these compounds was limited to the 16-foot and 30-foot screened zones suggesting that low levels of these compounds in soil vapor appear to be confined in the "upper fine" soils. Polygon 117 can be interpreted as displaying a top loaded vertical distribution of VOCs as opposed to the other three polygons investigated which were predominately bottom loaded.

Once all of the Phase II investigation data had been collected from the Class 2 polygons, the refined VLEACH and Mixing Cell screening was run utilizing the new, refined data (see Section 2.2). Investigated polygons which failed the refined VLEACH and Mixing Cell screening were prioritized by TCE impact to Subunit A ground water and for potential SVE remedy. Polygons failing the refined VLEACH and Mixing Cell screening that have not been investigated as outlined in the SVE Design Memorandum were prioritized for Phase I and II investigation and further refined VLEACH and Mixing Cell screening.

2.2 DATA ANALYSIS: TCE MASS, TOTAL DISTRIBUTION, VLEACH

As discussed in Section 2.0 of the May 1992 Design Memorandum, a series of numerical techniques were employed to estimate the potential impact to Subunit A ground water resulting from the vertical

leaching of TCE and related compounds from the vadose zone soils. Initially, M&E employed a very conservative screening method utilizing a total mass dissolution approach to the 143 polygons at the PGA site, in order to evaluate the impact to the Subunit A ground water resulting from leaching of TCE from vadose zone soils. This screening method is referred to in Section 2 of the May 1992 SVE Design Memorandum as Screening Method #1 (Total Mass Dissolution) and is described in detail therein in Section 2.2.2.2.

Utilizing Screening Method #1 for the 143 polygons located within Region 3 and Target Area 2 resulted in 63 polygons passing (ground water TCE concentrations $< 5 \mu\text{g/L}$), and 80 polygons failing the screening. This exercise was completed during the initial polygon prioritization effort in May 1992. The 80 polygons that failed this screening method were prioritized in terms of the relative threat posed to Subunit A ground water. The results of this screening test and the prioritization of the 80 failing polygons are summarized in Table 2-7. The top thirty-two (32) of the eighty (80) polygons determined to fail Screening Method #1 underwent either Phase I/Phase II investigation (polygons 92, 79, 116, and 117) or a second phase of VLEACH and Mixing Cell screening using a revised set of averaged, physical soil parameters to reevaluate whether total soil concentrations as TCE would result in Subunit A ground water concentrations in excess of $5.0 \mu\text{g/L}$.

Three U.S. EPA requested modifications, in the May 1992 Design Memorandum, that were finalized with U.S. EPA prior to conducting the field work, were made which are described below. During rescreening, it was discovered that a total of 79 polygons required rescreening, as polygon 27, originally considered as a separate, distinguishable polygon, is in fact grouped with the combined polygon 26-29, 32-35. As such, future polygon screening will focus on 79, as opposed to 80 polygons at the PGA site. Secondly, during the Phase II investigation conducted in May and June of 1992, M&E determined that the average depth to ground water was 60 feet below grade, as opposed to 62 feet below grade as specified in Appendix S, RI/FS, U.S. EPA, 1989.

Lastly, in order to standardize the screening of the 79 polygons, M&E has separated the 60 foot thick vadose zone into ten, 6-foot thick cells, as opposed to variable thickness cells presented in Appendix S, RI/FS, U.S. EPA, 1989. In order to preserve continuity of chemical data used to

Table 2-7

**Phoenix-Goodyear Airport Superfund Site
Polygon Screening Method # 1 Results**

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
POLYGON	MASS OF VOC (pounds)	AREA (sq. ft.)	VOLUME OF AQUIFER (cubic ft.)	VOLUME CONTAMINATED PORE WATER (cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (pounds/cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (ug/L)
92	47,920	87,500	5075000.00	2639000.00	1.82E-02	2.91E+05
116	2,328	130,000	7540000.00	3920800.00	5.94E-04	9.51E+03
117	1,944	143,500	8323000.00	4327960.00	4.49E-04	7.19E+03
79	375	85,000	4930000.00	2563600.00	1.46E-04	2.34E+03
65	334	80,500	4669000.00	2427880.00	1.38E-04	2.20E+03
113	568	155,000	8990000.00	4674800.00	1.22E-04	1.95E+03
96	220	83,000	4814000.00	2503280.00	8.79E-05	1.41E+03
87	211	75,000	4350000.00	2262000.00	9.33E-05	1.49E+03
41-43,8A-10	207	848,000	49184000.00	25575680.00	8.09E-06	1.30E+02
14A	251	127,500	7395000.00	3845400.00	6.53E-05	1.05E+03
111	354	192,500	11165000.00	5805800.00	6.10E-05	9.77E+02
36	187	107,500	6235000.00	3242200.00	5.77E-05	9.24E+02
13A	331	192,500	11165000.00	5805800.00	5.70E-05	9.13E+02
88	162	97,500	5655000.00	2940600.00	5.51E-05	8.82E+02
24A	240	162,500	9425000.00	4901000.00	4.90E-05	7.84E+02
69	143	102,500	5945000.00	3091400.00	4.63E-05	7.41E+02
93	73	52,500	3045000.00	1583400.00	4.61E-05	7.38E+02
84	237	171,000	9918000.00	5157360.00	4.60E-05	7.36E+02
70	114	91,500	5307000.00	2759640.00	4.13E-05	6.62E+02
27A	56	50,000	2900000.00	1508000.00	3.71E-05	5.95E+02
15A	138	147,500	8555000.00	4448600.00	3.10E-05	4.97E+02
66	40	64,000	3712000.00	1930240.00	2.07E-05	3.32E+02
32A	100	169,500	9831000.00	5112120.00	1.96E-05	3.13E+02
68	55	102,500	5945000.00	3091400.00	1.78E-05	2.85E+02
23A	64	129,000	7482000.00	3890640.00	1.64E-05	2.63E+02
114-115	123	251,700	14598600.00	7591272.00	1.62E-05	2.60E+02
21A,26A	66	148,500	8613000.00	4478760.00	1.47E-05	2.36E+02
153	41	112,000	6496000.00	3377920.00	1.21E-05	1.94E+02
98	25	85,000	4930000.00	2563600.00	9.75E-06	1.56E+02
64	19	80,000	4640000.00	2412800.00	7.87E-06	1.26E+02
151	7.2	31,500	1827000.00	950040.00	7.58E-06	1.21E+02
11A	20	90,000	5220000.00	2714400.00	7.37E-06	1.18E+02
38	26	120,000	6960000.00	3619200.00	7.18E-06	1.15E+02
103	18	83,500	4843000.00	2518360.00	7.15E-06	1.14E+02
26-29,32-35	188	875,000	50750000.00	26390000.00	7.12E-06	1.14E+02
51	15	79,000	4582000.00	2382640.00	6.30E-06	1.01E+02
62	15	80,000	4640000.00	2412800.00	6.22E-06	9.96E+01
6A	17	92,500	5365000.00	2789800.00	6.09E-06	9.76E+01
2A	7.6	44,000	2552000.00	1327040.00	5.73E-06	9.17E+01
80	29	228,500	13253000.00	6891560.00	4.21E-06	6.74E+01

Table 2-7 (Continued)

**Phoenix-Goodyear Airport Superfund Site
Polygon Screening Method # 1 Results**

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
POLYGON	MASS OF VOC (pounds)	AREA (sq. ft.)	VOLUME OF AQUIFER (cubic ft.)	VOLUME CONTAMINATED PORE WATER (cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (pounds/cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (ug/L)
5A	11	100,000	5800000.00	3016000.00	3.65E-06	5.84E+01
94	7.8	80,000	4640000.00	2412800.00	3.23E-06	5.18E+01
67	8.2	86,500	5017000.00	2608840.00	3.14E-06	5.03E+01
63	7.6	92,000	5336000.00	2774720.00	2.74E-06	4.39E+01
59-61	19.3	244,000	14152000.00	7359040.00	2.62E-06	4.20E+01
99	6.2	95,000	5510000.00	2865200.00	2.16E-06	3.47E+01
50	39	62,500	3625000.00	1885000.00	2.07E-05	3.31E+02
74	5.5	90,000	5220000.00	2714400.00	2.03E-06	3.25E+01
22A	4.3	70,500	4089000.00	2126280.00	2.02E-06	3.24E+01
90,37A	7.9	134,000	7772000.00	4041440.00	1.95E-06	3.13E+01
25A	4.7	80,000	4640000.00	2412800.00	1.95E-06	3.12E+01
39	5.4	114,500	6641000.00	3453320.00	1.56E-06	2.50E+01
28A	3.3	70,000	4060000.00	2111200.00	1.56E-06	2.50E+01
3A	3.3	73,500	4263000.00	2216760.00	1.49E-06	2.38E+01
12A	6.5	165,000	9570000.00	4976400.00	1.31E-06	2.09E+01
31	6.6	168,000	9744000.00	5066880.00	1.30E-06	2.09E+01
16A	4.1	105,000	6090000.00	3166800.00	1.29E-06	2.07E+01
52	1.9	54,000	3132000.00	1628640.00	1.17E-06	1.87E+01
46	7.1	212,500	12325000.00	6409000.00	1.11E-06	1.77E+01
150	10	317,500	18415000.00	9575800.00	1.04E-06	1.67E+01
27	2.5	93,500	5423000.00	2819960.00	8.87E-07	1.42E+01
54	1.6	67,500	3915000.00	2035800.00	7.86E-07	1.26E+01
45	1.7	73,000	4234000.00	2201680.00	7.72E-07	1.24E+01
102	1.8	80,500	4669000.00	2427880.00	7.41E-07	1.19E+01
33A	1.9	85,000	4930000.00	2563600.00	7.41E-07	1.19E+01
49	6.6	307,000	17806000.00	9259120.00	7.13E-07	1.14E+01
40	3.3	157,000	9106000.00	4735120.00	6.97E-07	1.12E+01
76	1.9	99,000	5742000.00	2985840.00	6.36E-07	1.02E+01
95	1.6	91,000	5278000.00	2744560.00	5.83E-07	9.34E+00
101	1.3	75,000	4350000.00	2262000.00	5.75E-07	9.21E+00
17A	2.8	163,500	9483000.00	4931160.00	5.68E-07	9.10E+00
44	3.4	216,500	12557000.00	6529640.00	5.21E-07	8.34E+00
1A	1.2	78,500	4553000.00	2367560.00	5.07E-07	8.12E+00
97	1.3	92,500	5365000.00	2789800.00	4.66E-07	7.46E+00
25	2.7	201,500	11687000.00	6077240.00	4.44E-07	7.12E+00
30	1.8	145,000	8410000.00	4373200.00	4.12E-07	6.59E+00
55-57	13.6	1,304,500	75661000.00	39343720.00	3.46E-07	5.54E+00
82	1.9	186,000	10788000.00	5609760.00	3.39E-07	5.43E+00
109	0.9	89,500	5191000.00	2699320.00	3.33E-07	5.34E+00
58,38A	1.5	154,500	8961000.00	4659720.00	3.22E-07	5.16E+00

Table 2-7 (Continued)

**Phoenix-Goodyear Airport Superfund Site
Polygon Screening Method # 1 Results**

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
POLYGON	MASS OF VOC (pounds)	AREA (sq. ft.)	VOLUME OF AQUIFER (cubic ft.)	VOLUME CONTAMINATED PORE WATER (cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (pounds/cubic ft.)	MAX. POSSIBLE GROUND WATER CONCENTRATION (ug/L)
37	3.6	387,500	22475000.00	11687000.00	3.08E-07	4.93E+00
104	0.8	87,500	5075000.00	2639000.00	3.03E-07	4.86E+00
91	0.7	78,000	4524000.00	2352480.00	2.98E-07	4.77E+00
152	1.6	185,000	10730000.00	5579600.00	2.87E-07	4.59E+00
100	0.5	70,000	4060000.00	2111200.00	2.37E-07	3.79E+00
47	0.4	59,000	3422000.00	1779440.00	2.25E-07	3.60E+00
119	0.6	92,000	5336000.00	2774720.00	2.16E-07	3.46E+00
89	0.5	80,000	4640000.00	2412800.00	2.07E-07	3.32E+00
77	0.4	74,000	4292000.00	2231840.00	1.79E-07	2.87E+00
86	0.8	158,500	9193000.00	4780360.00	1.67E-07	2.68E+00
120	0.4	87,500	5075000.00	2639000.00	1.52E-07	2.43E+00
26	0.5	122,500	7105000.00	3694600.00	1.35E-07	2.17E+00
105	0.3	75,000	4350000.00	2262000.00	1.33E-07	2.12E+00
34A	2	525,000	30450000.00	15834000.00	1.26E-07	2.02E+00
72	0.2	114,000	6612000.00	3438240.00	5.82E-08	9.32E-01
30A	0.1	60,000	3480000.00	1809600.00	5.53E-08	8.85E-01
118	0.2	120,000	6960000.00	3619200.00	5.53E-08	8.85E-01
75	0.2	127,500	7395000.00	3845400.00	5.20E-08	8.33E-01
29A	0.1	72,500	4205000.00	2186600.00	4.57E-08	7.33E-01
63	0.2	92,000	5336000.00	2774720.00	7.21E-08	1.15E+00
106	0.1	85,000	4930000.00	2563600.00	3.90E-08	6.25E-01
73	0.1	150,000	8700000.00	4524000.00	2.21E-08	3.54E-01
78	0	0	0.00	0.00	0.00E+00	0.00E+00
112	0	0	0.00	0.00	0.00E+00	0.00E+00
121	0	0	0.00	0.00	0.00E+00	0.00E+00
71	0	0	0.00	0.00	0.00E+00	0.00E+00
122	0	0	0.00	0.00	0.00E+00	0.00E+00
61	0	0	0.00	0.00	0.00E+00	0.00E+00
4A	0	0	0.00	0.00	0.00E+00	0.00E+00
106	0	0	0.00	0.00	0.00E+00	0.00E+00
7A	0	0	0.00	0.00	0.00E+00	0.00E+00
110	0	0	0.00	0.00	0.00E+00	0.00E+00
18A-20A	0	0	0.00	0.00	0.00E+00	0.00E+00
48	0	0	0.00	0.00	0.00E+00	0.00E+00
31A	0	0	0.00	0.00	0.00E+00	0.00E+00
107	0	0	0.00	0.00	0.00E+00	0.00E+00
65	0	0	0.00	0.00	0.00E+00	0.00E+00
53	0	0	0.00	0.00	0.00E+00	0.00E+00
35A	0	0	0.00	0.00	0.00E+00	0.00E+00
36A	0	0	0.00	0.00	0.00E+00	0.00E+00

estimate masses and concentrations of TCE existing in polygons at the PGA site, existing estimated mass data (fully distributed case) and existing total soil concentration data were input directly from the appendices of Appendix S, RI/FS, U.S. EPA, 1989. These data were then distributed into the ten, 6-foot thick cells for VLEACH input using the equilibrium equations presented on pages 89-90 of the May 1992 Design Memorandum, and Section 2.2.1 of this document. Table 2-8 lists the refined parameters utilized in the VLEACH screening.

TABLE 2-8

**SUMMARY OF SOIL PHYSICAL AND CHEMICAL PARAMETERS USED
IN DETERMINING TOTAL SOIL TCE CONCENTRATIONS ($\mu\text{g/Kg}$)**

PARAMETER	VALUE	UNITS
K_D	0.0915	L/Kg
f_{oc}	0.074%	Dimensionless
K_h	0.473	Dimensionless
C_g	Varies	$\mu\text{g/L}$
C_T	Varies	$\mu\text{g/Kg}$
ρ_b	1.64	g/cm^3
θ_T	38.1 %	Dimensionless
θ_w	25.5 %	Dimensionless
K_{oc}	123.6*	L/Kg
KgT	0.599	L/Kg
Depth to Ground Water	60	ft
* from Lyman (1982)		

Due to the general lack of complete and representative physical soil data from the vadose zone and the sparse soil vapor concentration data to develop vertical soil vapor distributions from ground surface to the ground water table, vadose zone soil physical data and soil vapor data were collected for input to the refined VLEACH and Mixing Cell screening. An arithmetic mean was employed

for the sixteen (16) soil samples analyzed to determine the average soil properties for each of the listed parameters. The refined soil physical parameters listed in Table 2-4 were used as input, for each of the 32 polygons during the refined VLEACH and Mixing Cell screening. Figure 2-6 presents a flow diagram which conceptually presents the methodology employed by M&E for the refined VLEACH and Mixing Cell screening which includes the following steps: Phase II soil vapor monitoring well sampling and analysis; total soil vapor to total soil concentration conversions; vertically distributing total soil concentrations throughout the four investigated polygons and extrapolating the vertical distribution data to all contiguous polygons using the computer program INTERP; running VLEACH and Mixing Cell using Phase II investigation data (physical and chemical) on the contiguous polygons, and applying Appendix S, 1989 RI/FS. U.S. EPA, 1987 data on the non-contiguous polygons not investigated in May, 1992; and finally determining the impact of vadose zone TCE to the Subunit A ground water.

Appendix M includes a printout of the VLEACH, Mixing Cell, and INTERP algorithms used for the polygon screening.

2.2.1 Polygon TCE Mass and Vertical Distribution Calculations

As stated in the previous section, 79 of the 143 polygons were determined to fail Screening Method #1, and thus require a second phase of investigation and/or rescreening using the VLEACH and Mixing Cell models. The averaged soil physical data collected during the Phase II investigation was applied to the 32 most contaminated of the 79 polygons failing Screening Method #1. For the four May, 1992-investigated polygons, new soil vapor chemical data collected from nested vapor wells during the Phase II field investigation was used for redefining the total VOC mass as TCE and vertically distributing TCE in soil for polygons 92, 79, 116, and 117. However, because no new soil chemical or soil vapor chemical data was available for the 28 non-investigated polygons that were screened, the chemical data handling requirements relied on existing chemical data and equations contained in Appendix A-D of Appendix S, RI/FS, U.S. EPA, 1989. These 28 additional polygons included polygons contiguous to the four investigated polygons, and non-contiguous, non-investigated polygons, which utilized different depth interval schemes based on respective

ESTIMATE MASS IN
VADOSE ZONE FROM:

- EXISTING APPENDIX S, RI/FS, U.S. EPA 1989 DATA (75 POLYGONS)
 - SOIL BORING DATA
 - SHALLOW SOIL GAS DATA
 - SOIL VAPOR EXTRACTION WELLS
- PHASE II SOIL GAS MONITORING WELL SAMPLE CONCENTRATIONS (4 POLYGONS)
- REVISED AVERAGED PHASE II PHYSICAL SOIL PROPERTIES (79 POLYGONS)



INPUT TOTAL SOIL CONCENTRATION VALUES (ug/Kg)
INTO THE TEN, SIX-FOOT THICK VERTICAL INTERVALS
FOR VLEACH MODEL INPUT



USE COMPUTER MODEL VLEACH TO ESTIMATE
TCE MOVEMENT IN AND FROM THE VADOSE
ZONE TO THE SUBUNIT A GROUNDWATER



USE SIMPLE MIXING CELL MODEL WITH
APPROPRIATE AQUIFER CHARACTERISTICS
TO ESTIMATE TCE IMPACT ON GROUNDWATER

APPROACH TO ESTIMATION OF TCE
IMPACTS ON GROUNDWATER
USING THE VLEACH MODEL



Metcalf & Eddy

Drawn by:
J. Weidmann

Job
Number:
006791

Date:
September 1992

Checked by:
S. Zachary

Figure Number:
2-6

Appendix S, RI/FS, U.S. EPA, 1989 sub-area designations (VPA, VPB, AC-4, 16-EP2, and 16EP-4). See Table 2-9 for a representation of the physical and chemical data applied to each of the 32 polygons for the refined VLEACH and Mixing Cell screening. Also, refer to Table 2-2 for a summary of the 79 investigated, contiguous, and non-investigated, non-contiguous polygons.

Four different chemical data handling cases were identified to exist in the 79 Class 1/Class 2 polygons, each of which required or will require future screening efforts and individually specific methodologies for calculating total TCE masses, and redistributing total soil concentrations for input into the revised ten, six-foot thick vertical soil intervals. The special cases for the polygons are identified as follows:

- Case 1 - Class 2 May 1992 investigated polygon: Polygon 92, 79, 116, or 117. Additionally, Polygon 69 has been treated as an investigated polygon based on investigative results conducted in July, 1992.
 - May 1992 Phase II averaged physical soil parameters
 - May 1992 Phase II soil vapor analytical data
- Case 2 - Class 1/Class 2 contiguous polygon: is directly contiguous to one of the four polygons investigated during the May 1992 Phase I/II investigation.
 - May 1992 Phase II averaged physical soil parameters
 - Appendix C, Tables C-2, revised estimate of VOC mass at PGA, 1989, total TCE mass estimate
- Case 3 - Class 1/Class 2 non-contiguous, non-investigated (1992): polygon located in either sub-area 16EP-2 or 16EP-4.
 - May 1992 Phase II averaged physical soil parameters
 - Appendix A, Tables A-1 through A-3, revised estimate of VOC mass at PGA site, 1989 soil vapor data
 - Appendix C, revised estimate of VOC mass at PGA site, 1989, vertical distribution equations

TABLE 2-9

**Physical and Chemical Data Application for 1992 Refined
VLEACH and Mixing Cell Screening**

Polygon Designation	Physical Data Source	Polygon Class Designation	Polygon Case # (1-4)*	Chemical Data Source
92	May, 1992	2	1	May, 1992
116	May, 1992	1	1	May, 1992
117	May, 1992	1	1	May, 1992
79	May, 1992	2	1	May, 1992
65	May, 1992	2	2	RI/FS , 1989
113	May, 1992	2	2	RI/FS , 1989
96	May, 1992	2	4	RI/FS , 1989
87	May, 1992	1	4	RI/FS , 1989
41-43	May, 1992	2	3	RI/FS , 1989
14A	May, 1992	2	3	RI/FS , 1989
111	May, 1992	2	3	RI/FS , 1989
36	May, 1992	2	3	RI/FS , 1989
13A	May, 1992	2	3	RI/FS , 1989
88	May, 1992	1	4	RI/FS , 1989
24A	May, 1992	2	3	RI/FS , 1989
69	May, 1992	1	1	RI/FS , 1989
84	May, 1992	1	4	RI/FS , 1989
15A	May, 1992	2	3	RI/FS , 1989
66	May, 1992	1	2	RI/FS , 1989
32A	May, 1992	2	3	RI/FS , 1989
68	May, 1992	1	2	RI/FS , 1989
23A	May, 1992	2	3	RI/FS , 1989
114-115	May, 1992	2	2	RI/FS , 1989
21A, 26A	May, 1992	2	3	RI/FS , 1989
153	May, 1992	1	2	RI/FS , 1989
64	May, 1992	1	2	RI/FS , 1989
11A	May, 1992	1	3	RI/FS , 1989
38	May, 1992	2	3	RI/FS , 1989
62	May, 1992	1	4	RI/FS , 1989
67	May, 1992	1	4	RI/FS , 1989
50	May, 1992	1	3	RI/FS , 1989
12A	May, 1992	1	3	RI/FS , 1989

* Polygon case designation (1,2,3, or 4): See section 2.2.1 for further discussion

Class 1 Designation = Pass VLEACH Screening

Class 2 Designation = Fail VLEACH Screening

- Case 4 - Class 1/Class 2 non-contiguous, non-investigated (1992) polygon: is located in either sub-area VPA, sub-area VPB, or sub-area AC-4.
 - May 1992 Phase II averaged physical soil parameters
 - Appendix D, Tables D-1 through D-12, revised estimate of VOC mass at PGA site, 1989 vertical distribution
 - INTERP revised vertical distribution (Section 2.2.1.4, and Table 2-14B)

Three separate sets of polygons (May 1992 Design Memorandum) have been identified based on the initial prioritization and are listed as follows:

- | | |
|---------|---|
| Class 2 | Polygon: failed initial Prioritization Method #1 and initial and subsequent VLEACH and Mixing Cell. |
| Class 1 | Polygon: failed Prioritization Method #1 but passed VLEACH and Mixing Cell screening. |
| Class 0 | Polygon: passed initial Prioritization Method #1. |

The following sections present the methodologies and equations employed for calculating the total VOC mass (as TCE) for investigated Polygons 92, 79, 116, and 117 and for determining the vertical distribution of mass in the investigated polygons. In addition, the methodology for redistributing Appendix S, RI/FS, U.S. EPA, 1989 total VOC masses as TCE into ten, 6-foot thick vertical soil intervals for the non-investigated polygons, and providing the necessary distributed total soil concentration data for input into the VLEACH and Mixing Cell screening models is presented.

2.2.1.1 Total Mass Estimate and Vertical Distribution for Case 1 Investigated Polygons

The methodologies for determining total polygon TCE masses and distributing the mass throughout the 60-foot thick vadose zone into ten, 6-foot cells for eventual input into VLEACH and Mixing Cell will be examined separately for each of the four cases applied to the screened polygons. Four depth-specific soil vapor samples were collected from each of the four investigated polygons (16 total plus additional QA/QC samples). Following the collection and analysis of soil vapor samples collected

from the Phase II soil vapor monitoring cluster wells in each of the four polygons, M&E compiled the data and performed calculations to convert the soil vapor VOC data (combined total soil vapor concentrations of TCE, PCE, 1,1-DCE, and 1,1,1-TCA in units of $\mu\text{g/L}$) to total soil concentrations as TCE in units of $\mu\text{g/Kg}$. The total soil vapor concentration was determined by summing the component soil vapor concentrations of TCE, PCE, 1,1-DCE and 1,1,1-TCA. Where a duplicate analyses was run on a sample, the highest component concentration for each of the four compounds was used in summing the total soil vapor concentration. A summary of the raw Phase II soil vapor monitoring well laboratory data for each of the four VOC's, and the summation of these VOC's to arrive at depth discrete, total VOC soil vapor concentrations as TCE is presented in Tables 2-10a through 2-10e for example Polygon 92. Shown in Table 2-10a is the sum of the component VOC's at the four sampled depths for the individual compounds 1,1-DCE (Table 2-10b), 1,1,1-TCA (Table 2-10c), TCE (Table 2-10d), and PCE (Table 2-10e). The first column of each table denotes the sample number, the second column denotes the sample concentration in units of ppbV, the third column indicates the sample concentration in units of $\mu\text{g/L}$, while the last column presents the total soil concentration ($\mu\text{g/Kg}$) based on using the following equations and parameters used to convert soil vapor concentrations ($\mu\text{g/L}$) to total soil concentrations ($\mu\text{g/Kg}$).

The following eight (8) equations were used to relate concentration and mass of contaminant in total soil, solid phase, liquid phase, and gas phase at equilibrium state:

$$C_T = \left[\left\{ \frac{K_D \rho_b + \theta_w}{k_h} + (\theta_T - \theta_w) \frac{1}{\rho_b} \right\} \right] C_g \quad (1)$$

$$C_L = \frac{C_g}{k_h} \quad (2)$$

$$C_s = (K_D \times 10^{-9}) C_L \quad (3)$$

$$M_T = C_T \rho_b \times 10^{-3} \quad (4)$$

TABLE 2-10a: Total Soil Concentration Calculations
from soil gas data for Polygon 92, June-1992

Sample #	Total Clx Conc (ppbV)	Total Clx Conc (ug/L)*	Total Clx Conc (ug/Kg)**
NA	0	0	0
VS-VP92-17	34926	143.01	85.66
VS-VP92-28	167400	693.00	415.11
VS-VP92-40	211300	887.00	531.31
VS-VP92-52	439800	2005.00	1201.00

* Laboratory ppbV to ug/L conversion

**Multiply ug/L concentration 0.599 L/Kg (calculated Kgt based on revised soil physical data)

TABLE 10b: 1,1-DCE Soil Concentration Calculations
from soil gas data for Polygon 92, June-1992

Sample #	1,1-DCE Conc (ppbV)	1,1-DCE Conc (ug/L)*	1,1-DCE Conc (ug/Kg)**
NA	0	0.00	0.00
VS-VP92-17	30000	116.00	69.48
VS-VP92-28	140000	540.00	323.46
VS-VP92-40	170000	660.00	395.34
VS-VP92-52	270000	1100.00	658.90

TABLE 10c: 1,1,1-TCA Soil Concentration Calculations
from soil gas data for Polygon 92, June-1992

Sample #	1,1,1-TCA Conc (ppbV)	1,1,1-TCA Conc (ug/L)*	1,1,1-TCA Conc (ug/Kg)**
NA	0	0.00	0.00
VS-VP92-17	96	0.51	0.31
VS-VP92-28	4800	26.00	15.57
VS-VP92-40	16000	85.00	50.92
VS-VP92-52	160000	850.00	509.15

TABLE 10d: TCE Soil Concentration Calculations
from soil gas data for Polygon 92, June-1992

Sample #	TCE Conc (ppbV)	TCE Conc (ug/L)*	TCE Conc (ug/Kg)**
NA	0	0.00	0.00
VS-VP92-17	4300	23.00	13.78
VS-VP92-28	20000	110.00	65.89
VS-VP92-40	22000	120.00	71.88
VS-VP92-52	7400	39.00	23.36

TABLE 2-10e: PCE Soil Concentration Calculations
from soil gas data for Polygon 92, June-1992

Sample #	PCE Conc (ppbV)	PCE Conc (ug/L)*	PCE Conc (ug/Kg)**
NA	0	0.00	0.00
VS-VP92-17	530	3.50	2.10
VS-VP92-28	2600	17.00	10.18
VS-VP92-40	3300	22.00	13.18
VS-VP92-52	2400	16.00	9.58

$$M_g = (\theta_T - \theta_w) C_g \times 10^{-3} \quad (5)$$

$$M_L = \theta_w C_L \times 10^{-3} \quad (6)$$

$$M_s = \rho_b C_s \times 10^{-6} \quad (7)$$

In these equations:

C_T = Total soil concentration ($\mu\text{g/kg}$)

C_L = Liquid phase concentration ($\mu\text{g/l}$)

C_s = Solid phase concentration (g/g , non-dimensional)

C_g = gas phase concentration ($\mu\text{g/l}$)

M_T = Mass of Contaminant in soil per unit bulk volume of soil ($\mu\text{g/cm}^3$)

M_L = Mass of contaminant in liquid phase per unit bulk volume of soil ($\mu\text{g/cm}^3$)

M_s = Mass of Contaminant in solid phase per unit bulk volume of soil ($\mu\text{g/cm}^3$)

M_g = Mass of contaminant in gas phase per unit bulk volume of soil ($\mu\text{g/cm}^3$)

The listed parameters incorporate the following units:

K_h = Henry's coefficient (non-dimensional)

K_d = Partition coefficient (L/Kg)

ρ_b = Dry bulk density of soil (g/cm^3)

ρ_{bulk} = Bulk density of soil (g/cm^3)

θ_T = Total porosity of soil (non-dimensional)

θ_w = Water filled porosity of soil (non-dimensional)

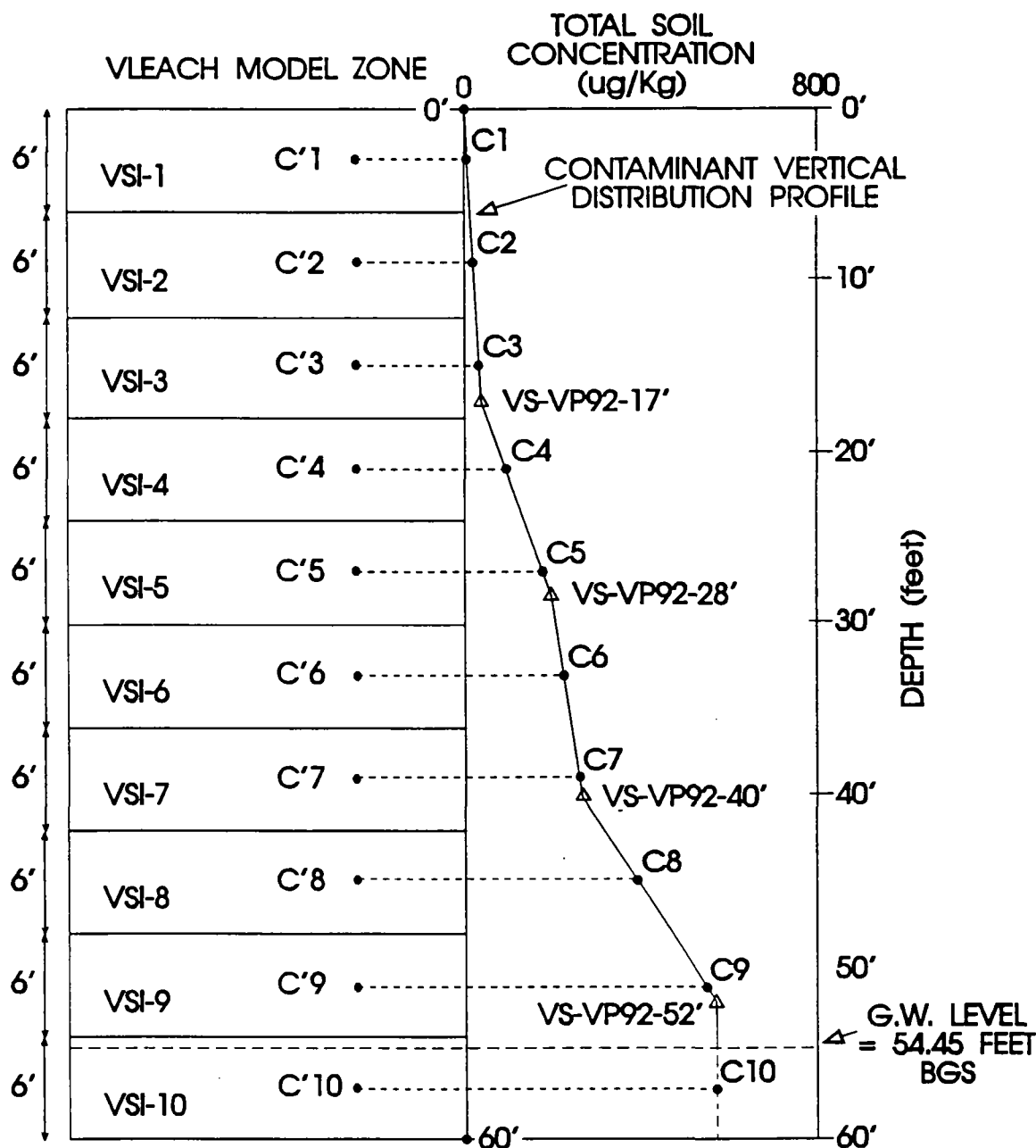
The relationship between bulk density and dry bulk density of soil is given as

$$\rho_{bulk} = \rho_b + \theta_w \rho_w \quad (8)$$

Here, ρ_w is the density of water (1 g/cm³).

Table 2-8 provides a list of the individual parameters appearing in equations 1-8, the selected values that are known, and those values that were calculated based on the averaged results of the Phase II soil physical testing.

Equation #1 listed above was used to directly convert depth specific total soil vapor concentrations determined through laboratory analysis of Phase II soil vapor well sampling at four different depth intervals, to total soil TCE concentrations on a dry bulk density basis. These depth-specific total soil concentration values were then distributed along a vertical profile to establish a vertical distribution profile throughout the entire vadose zone for each of the four investigated polygons (Figure 2-7). Figure 2-7 demonstrates for example Polygon 92 how converted total soil TCE concentrations were plotted and extrapolated such that the entire vadose zone vertical TCE contamination distribution was arrived at. The 60 foot thick vadose zone profile for the 4 investigated polygons that underwent refined VLEACH and Mixing Cell screening was divided into ten discrete 6-foot depth intervals. The total soil concentration data at four discrete vertical intervals (designated as VS-VP91-17 through VS-VP92-52) are plotted versus depth to form a vertical concentration profile. From the shallow (13-18 feet) vapor well in each of the four polygons investigated, the total soil concentration at depth was linearly extrapolated to a "zero" value at ground surface. This extrapolation is justified by Fick's First Law of Diffusion which describes a linear relationship between the concentration gradient established from a VOC source at depth to the ground surface (assumed to have no VOC concentration). The total soil concentration between VS-VP92-17 and VS-VP92-28, and between VS-VP92-28 and VS-VP92-40 (17-40 feet below grade) was based on a linear extrapolation between the known concentration points. The total soil concentration value between VS-VP92-52, the deepest (52-57 feet below ground surface) known total soil concentration point, extending to the ground water surface was estimated by extrapolating vertically downwards from the total concentration



VSI-1 = VERTICAL SOIL INTERVAL FOR VLEACH MODEL

△ VS-VP92-17 = TOTAL SOIL CONCENTRATION CALCULATED FROM DIRECT SOIL GAS CONCENTRATIONS

C1 = TOTAL SOIL CONCENTRATION INTERPOLATED FROM VS-VP92-17 TOTAL SOIL CONCENTRATION

• C'1 = INTERPOLATED TOTAL SOIL CONCENTRATIONS FOR VLEACH VERTICAL SOIL INTERVAL

NOTE: GROUND WATER TABLE DEPTH IS ASSUMED TO EXIST AT 60 FEET BELOW GROUND SURFACE. FOR POLYGON 92, GROUNDWATER WAS MEASURED AT 54.45 FEET BGS.

EXAMPLE CASE 1 VLEACH VERTICAL SOIL INTERVAL CONCENTRATION DETERMINATION INPUT

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September 1992
Figure Number:
2-7

corresponding to VS-VP92-52 (see Figure 2-7). This assumes that the concentration is constant from the deepest soil vapor sample to the top of the capillary fringe. In most cases, this extrapolated depth was less than 8 feet.

The completed vertical distribution profile for each of the four investigated polygons formed the basis as the input files to run the program INTERP. A complete copy of the INTERP program is provided in Appendix M of this document. The program INTERP, written specifically for the PGA site, accepts two dimensional data in the form of depth (feet below grade) and concentration ($\mu\text{g/Kg}$). The program INTERP reads the depth:concentration values entered into an input file for each polygon and asks the user to input a depth value between the end points of the input data (in feet below grade) for the calculation of the interpolated total soil concentration along the linear interpolation line at the input depth. The program interpolates a corresponding concentration ($\mu\text{g/Kg}$) based on the data entered into the input file. The algorithm used to determine an interpolated concentration at a specified depth given known concentrations at depths above and below the specified depth is a simple mathematical interpolation. To illustrate how the computer program functions, Table 2-11a summarizes, for example Polygon 92, the input file, which is a summary of converted total soil concentration values at the four sampled depths. Table 2-11b, the output file, summarizes interpolated total soil concentrations corresponding to the midpoints of the ten, six-foot thick vertical soil intervals.

TABLE 2-11A EXAMPLE INTERP INPUT FILE FOR Polygon 92		
SAMPLE	TOTAL SOIL CONC ($\mu\text{G/Kg}$)	DEPTH (FEET BELOW GRADE)
NA	0	0
VS-VP92-17	85.66	17
VS-VP92-28	415.11	28
VS-VP92-40	531.31	40
VS-VP92-52	1201	52

TABLE 2-11B EXAMPLE INTERP OUTPUT FILE FOR Polygon 92	
DEPTH	INTERPOLATED CONCENTRATION
3	15.1
9	45.3
15	75.6
21	205.5
27	385.2
33	463.5
39	521.6
45	810.4
51	1145.2
57	1201.0

The interpolated total soil concentrations correspond to the midpoint depths of each of the ten vertical soil intervals for VLEACH screening (eg. 3-foot depth is midpoint of first 6-foot depth interval, 9-foot depth is midpoint of second 6-foot interval, etc.). The corresponding concentrations are simple, mathematically interpolated total soil concentrations based on the input data. The program INTERP was run in this fashion to determine total soil concentration data for each of the four investigated polygons between the depth-discrete sample locations.

In order to estimate the revised total mass of VOC's (as TCE), the output total concentration data from INTERP was entered in a table and a series of calculations were carried out to determine the total revised mass of VOC's as TCE in each of the four polygons. Table 2-12 presents the tabulated INTERP output total soil concentration data and calculations used to determine the total VOC mass as TCE for example Polygon 92. The first column in Table 2-12 lists the INTERP output data. The second column lists the mass of contaminant per unit bulk volume of soil (M_T). M_T was converted from the total soil concentration, C_T using Equation #4. From the mass of contaminant per unit bulk volume of soil, (M_T) in units of $\mu\text{g/cc}$, the total mass was calculated by multiplying M_T first by a conversion factor:

$$M_T (\mu\text{g/cc}) \times (1000 \text{ cc/liter}) \times (28.317 \text{ liters/ft}^3) = \mu\text{g/ft}^3$$

then by the volume of each cell in ft^3 :

$$\mu\text{g/ft}^3 \times ((6 \text{ ft} \times 87500 \text{ ft}^2) = \mu\text{g}$$

then by another conversion to reach pounds of VOC (as TCE):

$$\mu\text{g} / [(106 \mu\text{g/g}) \times (453.59 \text{ g/pound})] = \text{pounds TCE.}$$

As can be seen in Table 2-12, the total VOC mass in Polygon 92 as calculated from Phase II soil vapor data extracted from the nested soil vapor monitoring wells is estimated to be 261.68 pounds as opposed to the Appendix S, RI/FS, U.S. EPA, 1989 estimate of 47,920 pounds. The last column in Table 2-12 is a calculation of the percentage of total mass of TCE that exists in each 6-foot vertical soil interval. The calculation used to create this column was to divide the incremental mass (in pounds) for each interval by the total mass (261.68 pounds). The result gives a mass distribution by percentage for each of the four investigated polygons (92, 79, 116, 117). A summary of the calculation tables for the four investigated polygons are presented in Appendix I. This vertical mass distribution percentage was used to redistribute Appendix S, RI/FS, U.S. EPA, 1989 total estimated mass data (fully distributed case) for each of the eleven contiguous polygons (see next section).

2.2.1.2 Vertical Distribution for Case 2, contiguous polygons

The six contiguous Case 2 polygons consist of polygon 66 (contiguous to investigated Polygon 92); polygon 153 (contiguous to investigated polygon 79), polygon 114-115 (contiguous to investigated polygon 116), and polygons 64, 65, and 68 (contiguous to investigated Polygon 69). The methodology employed to redistribute total soil VOC concentrations as TCE for these Case 2 polygons is described below using Polygon 66 as an example. Since Polygon 66 is a non-investigated, contiguous polygon to the investigated Polygon 92, M&E's approach was to use the Phase II revised soil physical parameters (Table 2-4), the total estimated VOC mass (as TCE) in

TABLE 2-12

Polygon 92 Vertical Distribution (as Percentage Total Mass) Calculations using Phase II Chemical and Physical Soil Data						
Ct (ug/Kg) M&E June, 92	Depth Interval Feet	Mt (ug/cc)	Volume Soil (cu. ft)	Mass TCE (grams) over depth interval	Incr. Mass Lbs	% of Total Mass per Interval
15.12	6	0.0247968	525000	368.64	0.81	0.003105762
45.35	6	0.074374	525000	1105.68	2.44	0.009315233
75.58	6	0.1239512	525000	1842.71	4.06	0.015524703
205.46	6	0.3369544	525000	5009.31	11.04	0.042203037
385.16	6	0.6316624	525000	9390.56	20.70	0.079114776
463.53	6	0.7601892	525000	11301.30	24.92	0.095212566
521.63	6	0.8554732	525000	12717.83	28.04	0.107146745
810.35	6	1.328974	525000	19757.09	43.56	0.166452016
1145.19	6	1.8781116	525000	27920.81	61.56	0.235230683
1201	6	1.96964	525000	29281.51	64.56	0.246694479
4868.37	60			118695.42	261.68	1.00

*Using Kgt term of 0.599 L/Kg

Appendix S, RI/FS, U.S. EPA, 1989, and the Polygon 92 vertical percentage of total mass profile established after completion of the Phase II, May, 1992 field investigation (see Table 2-12).

For Polygon 66, the Appendix S, RI/FS, U.S. EPA, 1989 estimated mass based on a fully distributed case is 40.3 pounds (see Table C-2 of Appendix S). By multiplying the contiguous Polygon 92 mass percentage distribution (Table 2-12) by 40.3 pounds, a redistributed mass profile similar to Polygon 92 is achieved (totalling 40.3 pounds). Table 2-13 presents vertical distribution calculations for Polygon 66. Columns 1-3 on Table 2-13 show this step. Columns 3-5 distribute the mass per six foot interval and calculate the total soil concentration in $\mu\text{g/Kg}$ based on the mass per volume of soil in each interval as follows:

$$\text{pounds} \times (453.59 \text{ grams/pound}) \times (10^6 \mu\text{g/gram}) = \mu\text{g}$$

next:

$$\mu\text{g} / (315000 \text{ ft}^3) \times (28.317 \text{ liters/ft}^3) = \mu\text{g/L}$$

lastly:

$$\mu\text{g/L} \times (\text{bulk dry density: } 1.64 \text{ Kg/liter}) = \mu\text{g/Liter}$$

Using these relationships, column 6 of Table 2-13 presents the redistributed total soil concentration data in $\mu\text{g/Kg}$ using the contiguous Polygon 92 vertical distribution, Appendix S, RI/FS U.S. EPA, 1989 estimated VOC mass (as TCE) for example Polygon 66. The remaining five contiguous polygons were treated in the identical format where the vertical percent mass distribution from the contiguous investigated polygon was applied. A summary of these calculations for each of the six Case 2 polygons are presented in Appendix I.

TABLE 2-13

Polygon 66 Vertical Distribution Calculations using Phase II Polygon 92 Chemical Data and Physical Soil Data, and Estimated VOC Mass in pounds (as TCE) from HGC (July, 1989)					
% Total Mass per 6 ft Interval (from Polygon 92)	Total Mass VOC's (lbs) Polygon 66 (from HGC, 1989) (Table C-2)	Incremental mass (pounds) per 6 ft interval	Incremental mass (grams) per 6 ft interval	Volume Soil per interval (cu. ft)	Calculated Total Soil Conc. Ct (ug/Kg) using Polygon 92 Vert Dist and Revised Physical Soil Data
0.003105762	40.3	0.13	56.77	384000	3.18
0.009315233	40.3	0.38	170.28	384000	9.55
0.015524703	40.3	0.63	283.79	384000	15.91
0.042203037	40.3	1.70	771.46	384000	43.26
0.079114776	40.3	3.19	1446.19	384000	81.10
0.095212566	40.3	3.84	1740.45	384000	97.60
0.107146745	40.3	4.32	1958.61	384000	109.83
0.166452016	40.3	6.71	3042.69	384000	170.62
0.235230683	40.3	9.48	4299.94	384000	241.12
0.246694479	40.3	9.94	4509.50	384000	252.87
1.00		40.3	18279.68		

2.2.1.3 Vertical Distribution for Case 3 (16EP-2 and 16EP-4) Polygons

For the Case 3 non-investigated polygons located in Sub-Areas 16EP-2 or 16EP-4, the assumed linear contaminant distribution equations for the compound TCE were utilized as shown below (from Appendix D of Appendix S, RI/FS, U.S. EPA, 1989).

Sub-area 16EP-4

$$C_z = (3.023 * z - 11.38)C_s \quad (9)$$

Sub-area 16EP-2

$$C_z = (74.527 * z - 371.636) C_s \quad (10)$$

where:

C_z = Calculated concentration in soil vapor at depth z ($\mu\text{g/L}$)

z = Depth (ft)

C_s = Measured concentration at soil vapor survey point ($\mu\text{g/L}$)

Equation #9 was directly used to calculate depth specific soil vapor concentrations as TCE for Class 1 polygons located in sub-area 16EP-4, and Equation #10 used for Class 1 polygons located in sub-area 16EP-2.

Measured 1989 soil vapor survey concentration data (C_s) were extracted in kind from Appendix A of Appendix S, RI/FS, U.S. EPA, 1989. The soil vapor value (C_s) was determined by adding the component soil vapor values of the compounds TCE, PCE, 1,1-DCE, and 1,1,1-TCA as listed in Appendix A. Depth interval values (z) were input into the vertical distribution equations to solve for depth specific soil vapor concentrations. The midpoint depths of each six-foot thick vertical soil interval (eg. $z = 3$ feet is midpoint of first six-foot interval, $z = 9$ feet is midpoint of second interval, 15 feet, 21 feet, ... $z = 57$ feet is midpoint of deepest 54-60 foot vertical soil interval) were input into the equations to solve for C_z . The approach for employing midpoints at each 6-foot depth interval was designed to mimic the Phase II vertical soil vapor investigation data usage for the four

investigated polygons. The result of using these equations yielded a depth-specific soil vapor concentration (C_v) in units of $\mu\text{g/L}$, which after being multiplied by the K_{gT} soil vapor to total soil concentration conversion term described in Section 2.2.1.1, yielded the total soil concentration distribution ($\mu\text{g/Kg}$) for each of the polygons from 0-60 feet below grade. A summary of the tabulation and calculations for determining vertical total soil concentration distributions for the Case 3 polygons are presented in Appendix I.

2.2.1.4 Vertical Distribution for Case 4, non-investigated Polygons

The Case 4 non-contiguous, non-investigated polygons are located in the sub-areas designated as VPA, VPB, and AC-4. Total soil concentration data for these polygons was extracted in kind from Tables D-1 through D-12 in Appendix S, RI/FS, U.S. EPA, 1989. The total soil concentration values used as input at each vertical depth interval were determined by summing the component concentrations of 1,1-DCE, 1,1,1-TCA, TCE, and PCE. The methodology used to redistribute existing estimated total soil concentrations using existing vertical soil intervals into ten, six-foot thick vertical soil intervals employed a three step process which is described below. As an example of this methodology, Tables 2-14a and 2-14b are provided which summarize calculations for Polygon 96. Initially, original 1986/1987 RI/FS total soil concentration data were input and converted to total mass in pounds using the equilibrium equations presented in Section 2.2.1.1. Referring to Table 2-14a, columns 1-3 present the original vertical depth intervals and total soil concentration data from Appendix S, RI/FS, U.S. EPA, 1989.

Column 4 presents the conversion of total soil concentrations into mass of contaminant per bulk volume of soil (M_T) using equation #4 (see section 2.2.1.1). Multiplying the M_T term by the total soil volume per interval (using the Appendix S, RI/FS, U.S. EPA, 1989 soil interval scheme) while converting cubic centimeters (cc) to cubic feet (ft^3) and μg to pounds as described earlier, the calculated mass of total VOC's as TCE is 83.38 pounds. This process is iterated over each depth interval (to 62.5 feet bgs in this case) until the total estimated mass of TCE in pounds is calculated as 248.88 pounds. It should be noted that the depth intervals used are variable in accordance with the 1989 RI/FS.

The second step is to enter the total soil concentration values into the computer program INTERP in a fashion identical to that employed for the investigated polygons. The total soil concentration input data were taken directly from Tables D-1 through D-12 of Appendix S, RI/FS, U.S. EPA., 1989, where TCE is actually the sum of the four VOC compounds, identical to the approach used in screening the other polygons at the PGA site. Table 2-14b presents the calculations and values associated with redistributing total soil concentrations. Table 2-14c is a sample INTERP input file for Polygon 96.

The INTERP input depths for the corresponding total soil concentrations are selected to nearly overlap each vertical soil interval for Polygon 96 (e.g. a concentration of 1635.33 $\mu\text{g/Kg}$ at 1-6 foot depth corresponds to first 0-6 foot interval, 147.18 $\mu\text{g/Kg}$ at 6.5-12 foot depth corresponds to 6-12 foot interval, etc.). The result of this approach is to closely approximate the actual mass of TCE existing in each polygon screened using the existing vertical distribution.

This approach resulted in a total VOC mass discrepancy of less than 2% between the 1989 RI/FS data and the currently employed VLEACH data, which is considered as negligible with respect to the modelling results.

The methods described for Case 1 through Case 4 polygon data handling generated total soil concentration vertical distributions for all 32 screened polygons. These data were directly entered into VLEACH input files using the ten, 6-foot thick cells, comprising a total vadose zone thickness of 60 feet. Results of the VLEACH modelling are presented in the next section.

2.2.2 VLEACH Modelling Results

Following completion of the Phase I/II field investigation, collection of the revised physical and chemical soil parameters, and redistributing the Phase II soil vapor laboratory results for the four investigated polygons or Appendix S, RI/FS, U.S. EPA, 1989 total soil concentration data (for the non-investigated polygons) into VLEACH input files (Section 2-1), M&E systematically used the VLEACH and Mixing Cell models to complete the revised screening of 32 of the 79 total polygons

TABLE 2-14A

Calculation of Total VOC Mass (as TCE) in Polygon 96
using HGC Distribution and original Depth Intervals

Depth Interval (ft) (HGC, 1989)	Depth (ft)	Total Soil Conc. Ct*(ug/Kg) VOC's as TCE (HGC, 1989) (Table D-5)	Mt (ug/cc)	Volume Soil (cu. ft)	Mass of Contaminant (grams)	Mass of Contaminant (pounds)
0-6	6	1635.33	2.6819412	498000	37820.38	83.38
6-12	6	147.18	0.2413752	498000	3403.84	7.50
12-22	10	169.41	0.2778324	830000	6529.93	14.40
22-32	10	178.61	0.2929204	830000	6884.54	15.18
32-41	9	512.59	0.8406476	747000	17782.05	39.20
41-47.5	6.5	935.28	1.5338592	539500	23432.80	51.66
47.5-52.5	5	353.41	0.5795924	415000	6811.11	15.02
52.5-57.5	5	206.47	0.3386108	415000	3979.20	8.77
57.5-62.5	5	324.02	0.5313928	415000	6244.69	13.77
Totals:	62.5				112888.54	248.88

* Based on sum of four VOC concentrations listed in Tables D-1 - D-4 of HGC, 1989.
Area of Polygon 96: 83000 square feet

TABLE 2-14B

Polygon 96 Calculation of Total TCE Mass in Sub-Unit A. Redistributing Total Soil Concentrations using INTERP and original HGC Total Soil Concentrations and Vertical Distributions to derive new VLEACH vertical distribution input data.

Depth Interval (feet)	Depth (feet)	Total Soil Conc INTERP Ct (ug/Kg)	Mt (ug/cc)	Volume Soil (cubic feet)	Mass TCE in interval (grams)	Mass TCE in interval (lb)
0-6	6	1635.33	2.68	498000	37820.38	83.38
6-12	6	147.18	0.24	498000	3403.84	7.50
12-18	6	169.41	0.28	498000	3917.96	8.64
18-24	6	169.41	0.28	498000	3917.96	8.64
24-30	6	178.61	0.29	498000	4130.72	9.11
30-36	6	512.59	0.84	498000	11854.70	26.14
36-42	6	512.59	0.84	498000	11854.70	26.14
42-48	6	935.28	1.53	498000	21630.28	47.69
48-54	6	353.41	0.58	498000	8173.33	18.02
54-60	6	206.47	0.34	498000	4775.04	10.53
Totals:	60				111478.91	245.77

TABLE 2-14C EXAMPLE INTERP INPUT FILE FOR POLYGON 96	
TOTAL SOIL CONC ($\mu\text{g/Kg}$)	TOP OF VLEACH DEPTH INTERVAL (FEET BELOW GRADE)
1635.330	1.00
1635.330	6.00
147.180	6.50
147.180	12.00
169.410	12.50
169.410	22.00
178.6610	22.50
178.610	32.00
512.590	32.50
512.590	41.00
935.280	41.50
935.280	47.50
353.410	48.00
353.410	52.50
206.470	53.00
206.470	57.50
324.020	58.00
324.020	60.00

failing Screening Method #1. Figure 2-6 presents a conceptual flowchart which describes the following elements: Phase I/Phase II investigation data usage, the decision process used to treat polygons falling in either the Class 1 or Class 2 category, and the role that both the VLEACH and Mixing Cell models play in arriving at the decision of whether to drop a particular polygon from further SVE remedy consideration, or to prioritize a polygon for subsequent Phase I/Phase II investigation and/or potential SVE remediation as the operable unit remedy.

VLEACH input data consisting of distributed total soil concentration data at ten, 6-foot vertical soil intervals (60 feet total) was discussed in section 2.2.1 and appears in Appendix I for each polygon. Summary input and output files for each of the 32 polygons investigated are also included in Appendix I listed in ascending order from the lowest number polygons first, with all polygons followed by an "A" designation presented last. Refer to Drawing P-1, Appendix K for the location of the site polygons.

The VLEACH program is a relatively simple, one-dimensional, finite difference model which simulates three-phase equilibria and vertical transport of volatile compounds from the vadose zone into the underlying ground water. Individual cells or "polygons" are treated independently of one another during each run. The polygons in turn are represented by a vertical stack of "cells" or vertical soil intervals which, when combined, extend from ground surface to the water table. The polygons during this modeling effort were assumed to have similar soil properties (see Table 2-4), cell thickness (6-feet), and depth to ground water (60 feet; see Section 2.2), however, the vertical distribution of TCE in the vadose soils, the recharge rate and the surface area of each polygon were variable between the screened polygons (see Table 2-7). Table 2-8 presents a summary of the physical soil parameters used for the initial VLEACH Screening. Table 2-15 provides a summary of the equation variables used in VLEACH and their definitions. Appendix M contains a copy of the complete VLEACH program algorithm.

The approach used to calculate the ground water impacts was to first calculate the movement of the VOC contaminants in the vadose zone to the water table, and then to estimate the mass loading to the ground water over time. The input mass in terms of total soil concentration ($\mu\text{g/Kg}$) within each cell is partitioned by VLEACH among three phases: contaminant dissolved in a liquid phase, C_L , contaminant existing as a vapor phase, C_g , and contaminant sorbed to the organic fraction of the vadose zone soil, C_s . The analysis also addressed the diffusion of vapor phase contamination into and out of surrounding soil cells, and liquid transport (advection) of vadose zone water downward to the capillary fringe and ground water. For simulation purposes, the VLEACH Model time step was set at one year intervals, with a total simulation time of thirty years. Figure 2-6 presents a schematic representation of the data usage requirements leading up to the implementation of the

TABLE 2-15
VLEACH EQUATION VARIABLE DEFINITIONS

PARAMETER	DESCRIPTION	VALUE
M_T	Total mass of contamination in a model cell [M]	varies
ΔZ	Thickness of cells in VLEACH calculation [L]	6 feet
n	Total porosity of soil [dimensionless]	0.381
θ	Water-filled porosity of soil [dimensionless]	0.255
ρ_b	Bulk density of soil [M/L ³]	1.64
K_D	Distribution coefficient for soil-water partitioning [L ³ /M]	0.0915
K_h	Henry's constant for air-water partitioning [dimensionless]	0.473
C_s	Contaminant concentration in sorbed phase [M/M]	Varies
C_L	Contaminant concentration in the liquid phase [M/L ³]	Varies
C_g	Contaminant concentration in the gas phase [M/L ³]	Varies
f_{oc}	Fraction organic carbon in soil [dimensionless]	0.00074
K_{oc}	Organic carbon partition coefficient [L ³ /M]	123.6
D	Effective diffusion coefficient [L ² /T]	1.796
q	Darcian flux of percolating water [L/T]	Varies
In finite difference equations:		
$C_{i-1}^{t+\Delta}$		
C	Refers to concentration of gas or liquid, depending on the equation [M/L ³]	
$t+\Delta t$	Refers to the time step at which the concentration is calculated.	
$i-1$	Refers to the cell number in which the concentration is calculated.	

VLEACH model. Appendix I contains the abridged test run results, and calculations of total soil concentrations ($\mu\text{g/Kg}$) for each screened polygon.

The results of the VLEACH modelling for the 32 polygons are graphically presented in terms of mass flux of TCE into the Subunit A ground water table over a thirty-year modeling duration (see Figures 2-8 through 2-11). The mass loading data used to generate these graphs corresponds to the VLEACH output file for each of the 32 screened polygons. A tabulation of the raw mass loading data from VLEACH is included as tables in Appendix I. The order of polygons listed in Figures 2-8 through 2-11 have been prioritized in terms of greatest threat to raising Subunit A TCE ground water concentrations above $5 \mu\text{g/L}$. An important point to note from these figures is that peak TCE mass flux into the Subunit A ground water is realized within the 30-year timeframe for 29 of the 32 polygons screened. The three exceptions to this trend include Polygons 84, 87, and 88, which are all located in sub-area AC-4. For these polygons, peak mass flux is largely affected by "top loaded" vertical distributions evident in Tables D-1 through D-12 of Appendix S, RI/FS, U.S. EPA, 1989. Contrasting the distribution of sub-area AC-4, the results of the Phase II vertical soil vapor investigation indicated that total VOC concentrations as TCE occurring in the vadose zone were bottom loaded (eg. TCE mass increases with depth). This "bottom loading" trend was also inferred to exist at sub-areas 16EP-2 and 16EP-4.

2.2.3 Mixing Cell Modelling Results

The results of the VLEACH modelling established ground water TCE mass flux output files that were directly input into the program Mixing Cell. The Mixing Cell program was developed by M&E in order to directly interface with the VLEACH model and facilitate timely calculations of resultant ground water TCE concentrations based on input TCE mass loading data. Specifically, VLEACH output files for each of the screened polygons listing TCE mass loading in grams over time were directly read into the Mixing Cell program and through a series of calculations, resultant TCE ground water concentrations were determined. A complete narrative describing the Mixing Cell routines that were employed to calculate the TCE ground water concentrations using the Mixing Cell model are included in Appendix I. The Mixing Cell program was used to determine Subunit A

Figure 2-8 a

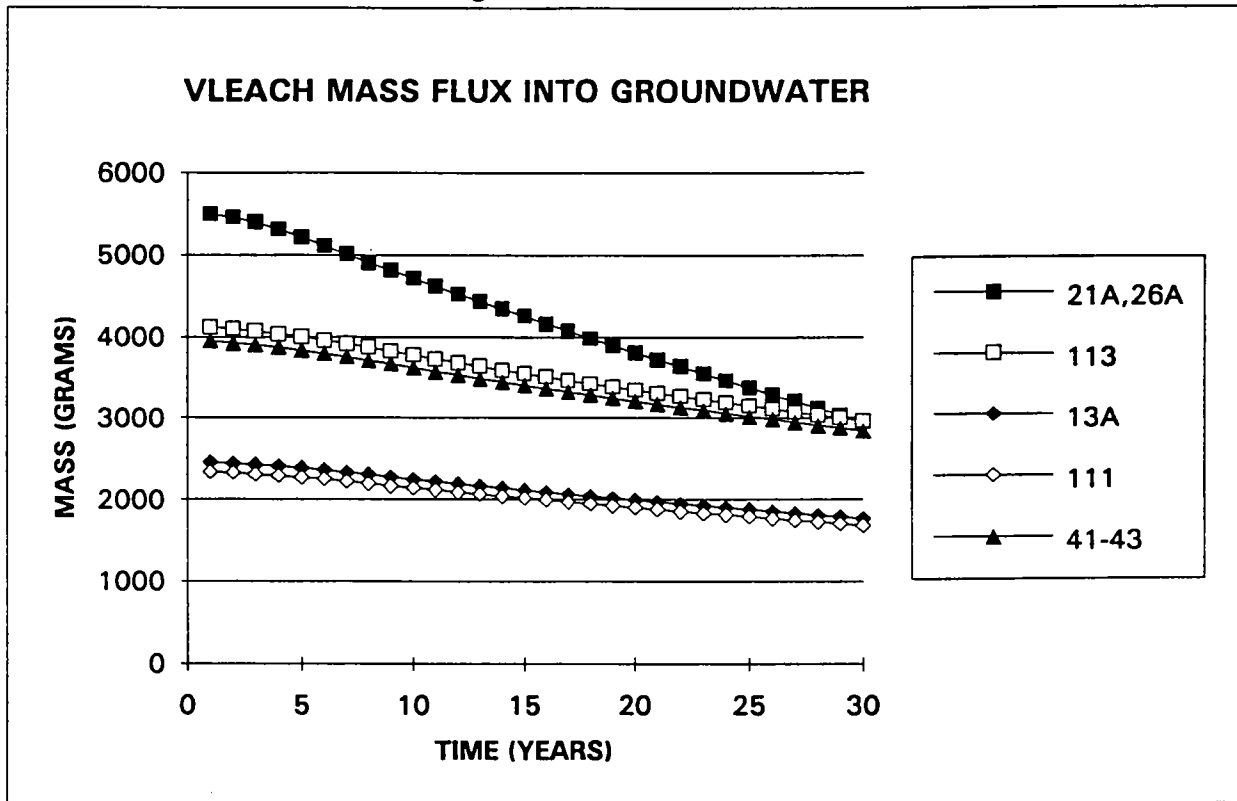


Figure 2-8 b

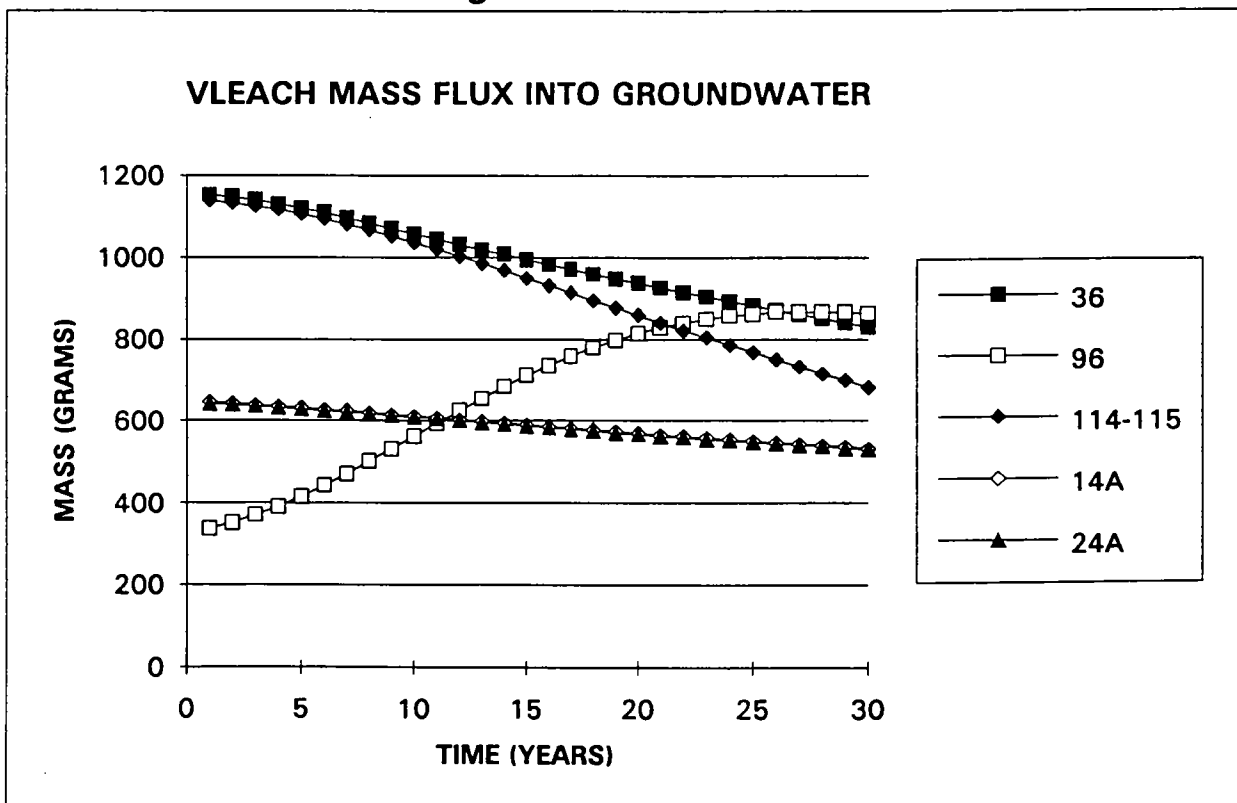


Figure 2-9 a

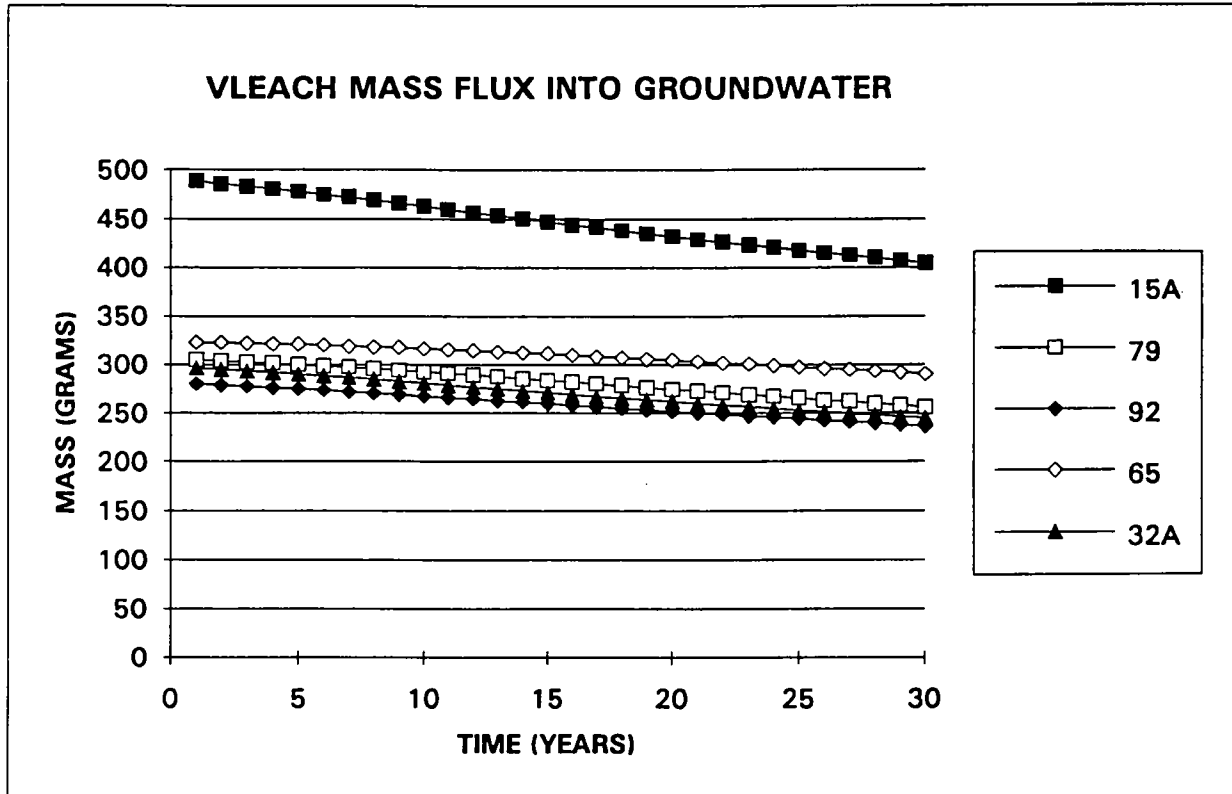


Figure 2-9 b

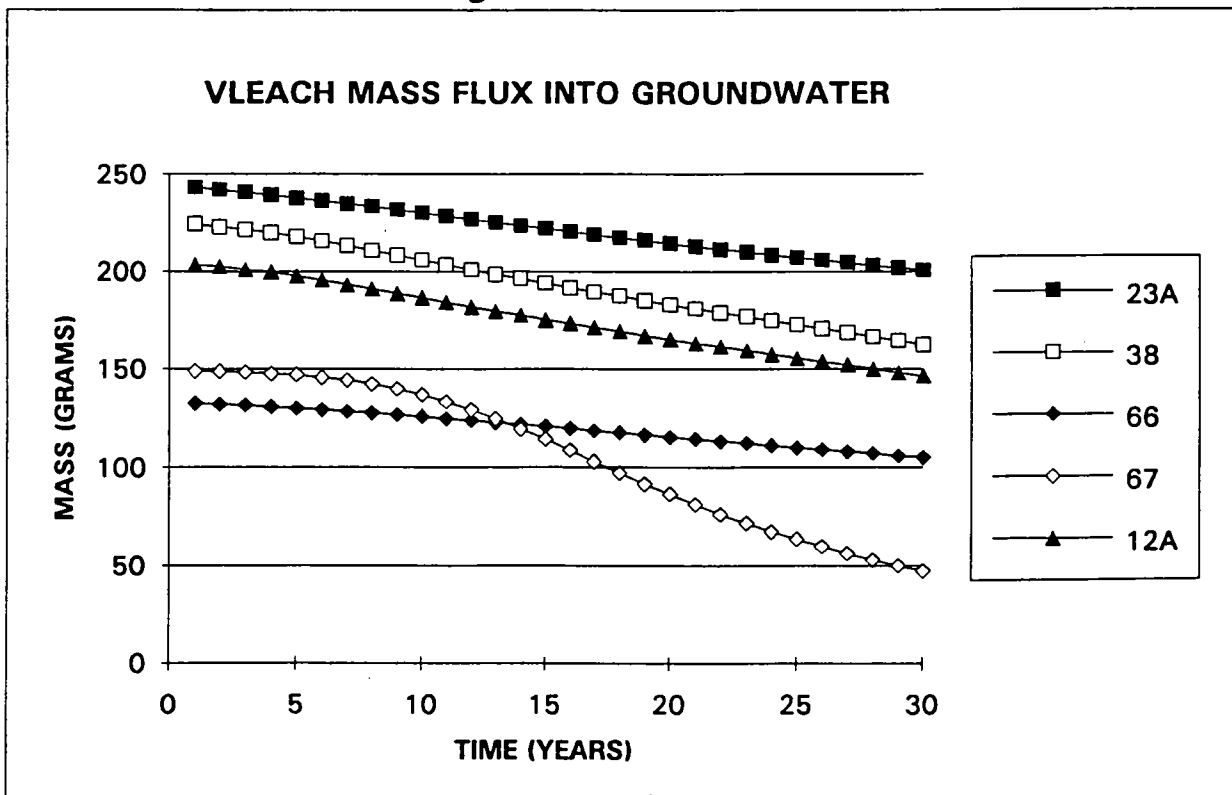


Figure 2-10 a

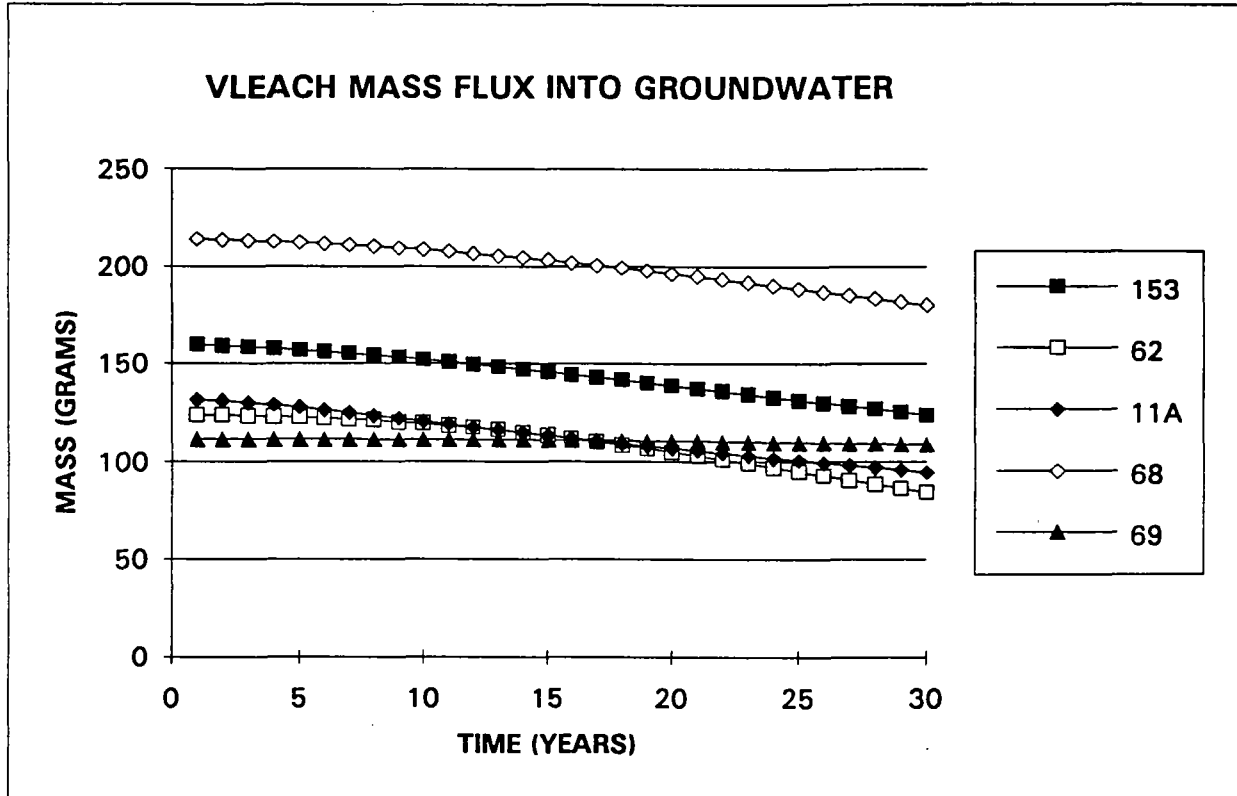


Figure 2-10 b

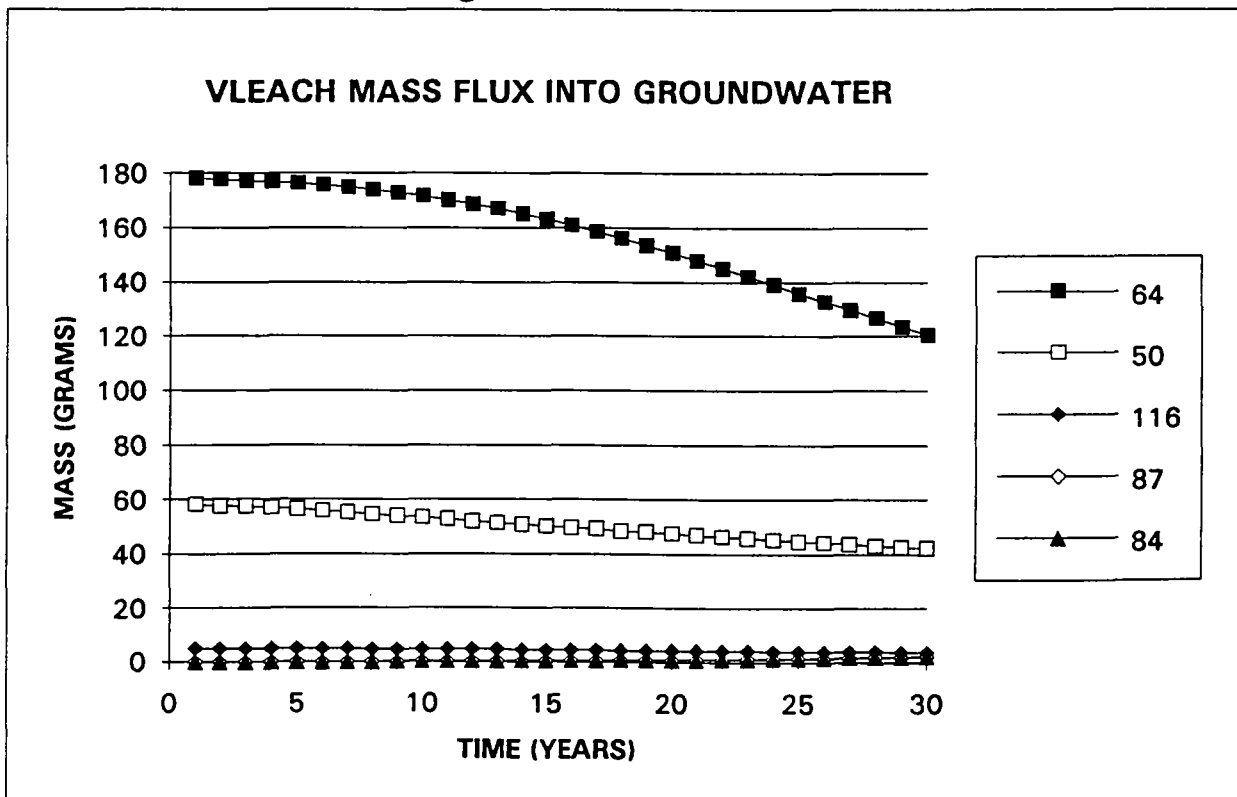
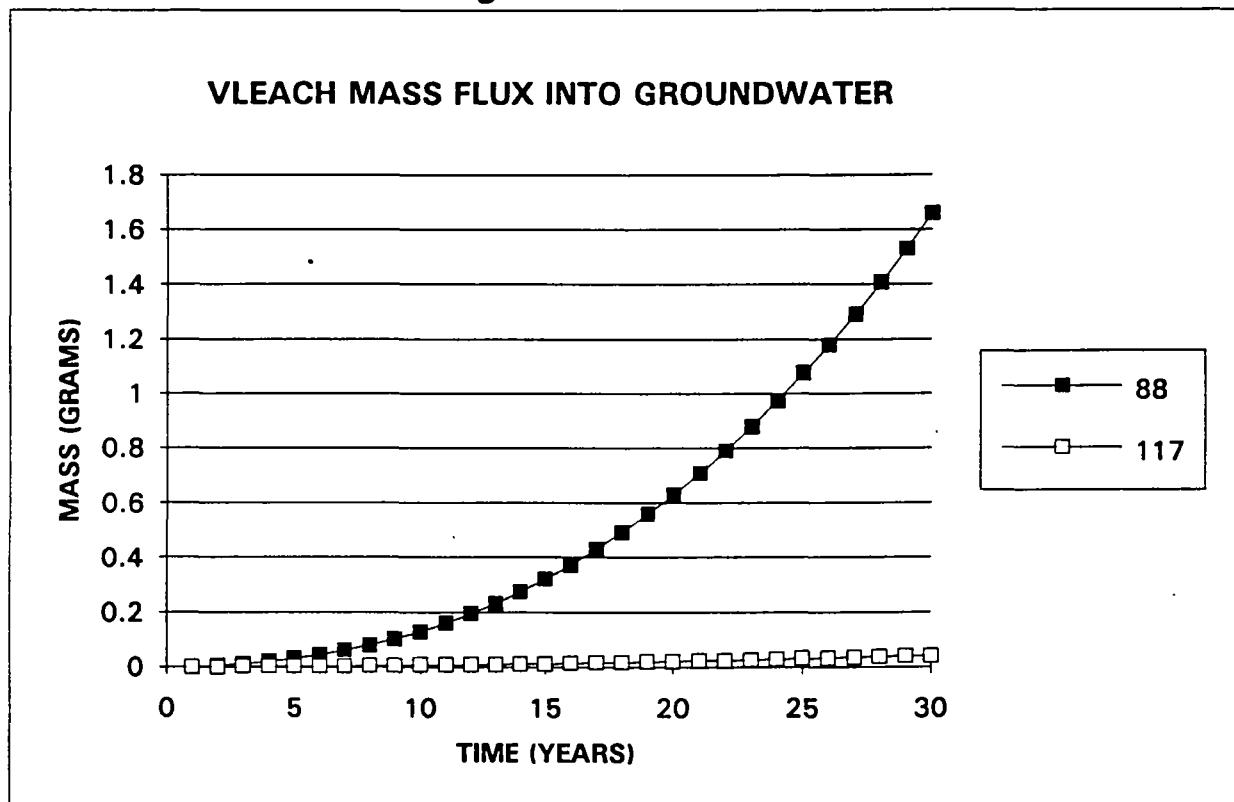


Figure 2-11



ground water TCE impact over a 30-year timeframe. Ground water flow dynamics within the Subunit A aquifer were calibrated to site derived aquifer parameters listed in Table 2-16. These parameters were derived from the 1989 RI/FS. The Mixing Cell program was written to calculate ground water TCE concentrations on a one-tenth of a day basis, and to print out the ground water impact summary on an annual basis for a thirty-year total model duration.

TABLE 2-16
SUBUNIT A AQUIFER PARAMETERS

Transmissivity (gpd/ft)	20,000 ⁽¹⁾
Hydraulic Conductivity (gpd/sq. ft)	344.83
Hydraulic Gradient (ft/ft)	0.00421 ⁽¹⁾
Depth of Aquifer (ft)	60 ⁽²⁾
Flow Field Width (ft)	(Area) ^{1/2}
⁽¹⁾ From U.S. EPA RI/FS, Vol. VI, Appendix S, 1989; and U.S. EPA RI/FS, Vol. IX, Appendix V, 1989.	
⁽²⁾ From May 1992, Phase I/Phase II field investigation.	

The Mixing Cell screening results are presented as ground water TCE concentrations ($\mu\text{g/L}$) graphed at one year printout intervals over a thirty year timeframe in Figures 2-12 through 2-15 for the 32 screened polygons. A horizontal line extrapolated from the clean-up level of 5 $\mu\text{g/L}$ on the y-axis has been included on each graph for reference. As shown in these figures, seventeen (17) polygons of the thirty-two (32) polygons were determined to fail the combined VLEACH and Mixing Cell modelling as indicated by Subunit A ground water TCE concentrations in excess of 5 $\mu\text{g/L}$ over the thirty-year timeframe. Out of the ten (10) highest prioritized polygons that were determined to fail the VLEACH and Mixing Cell screening, nine (9) of these polygons are located within the sub-area designated as 16-EP2. As discussed in Section 2.2.1.3, using equation #10, vertical total soil concentration profiles are skewed to a "bottom loaded" distribution which linearly increases with depth. Although bottom loaded profiles were displayed in three of the four Phase I/Phase II investigated polygons, the

Figure 2-12 a

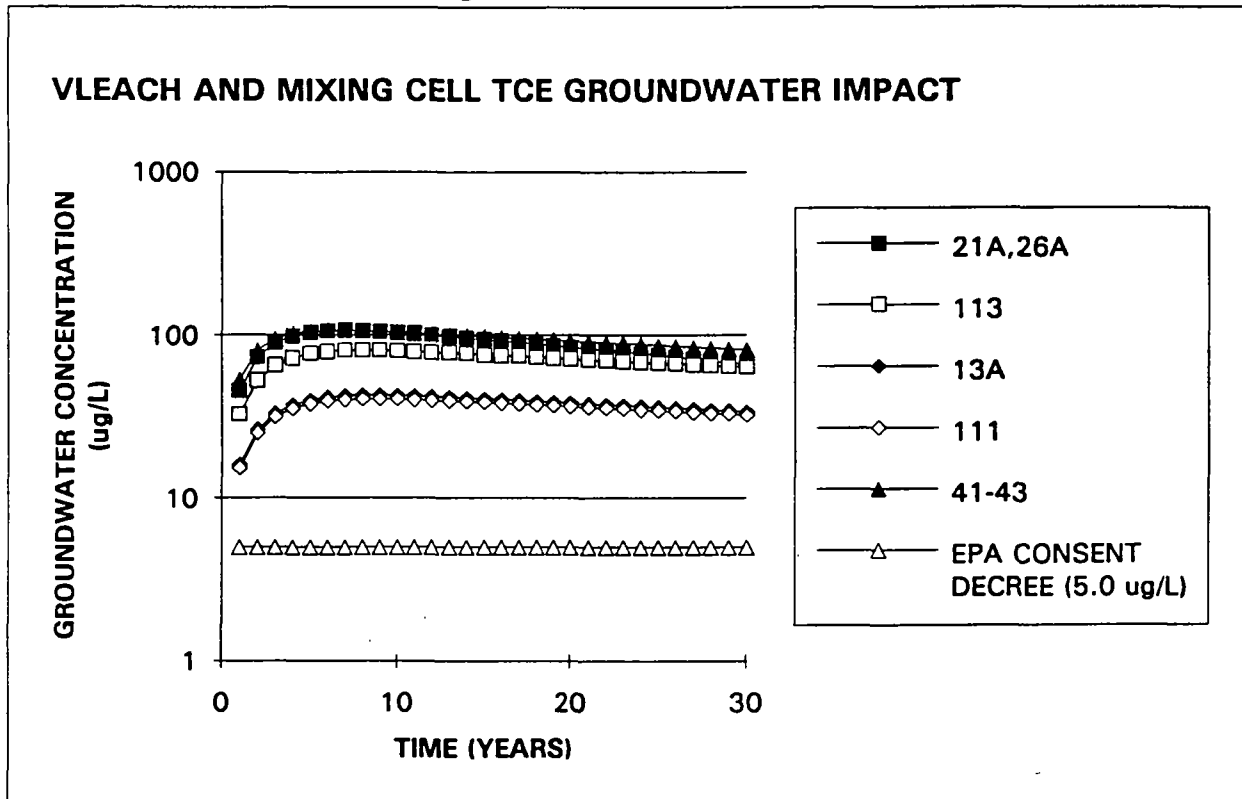


Figure 2-12 b

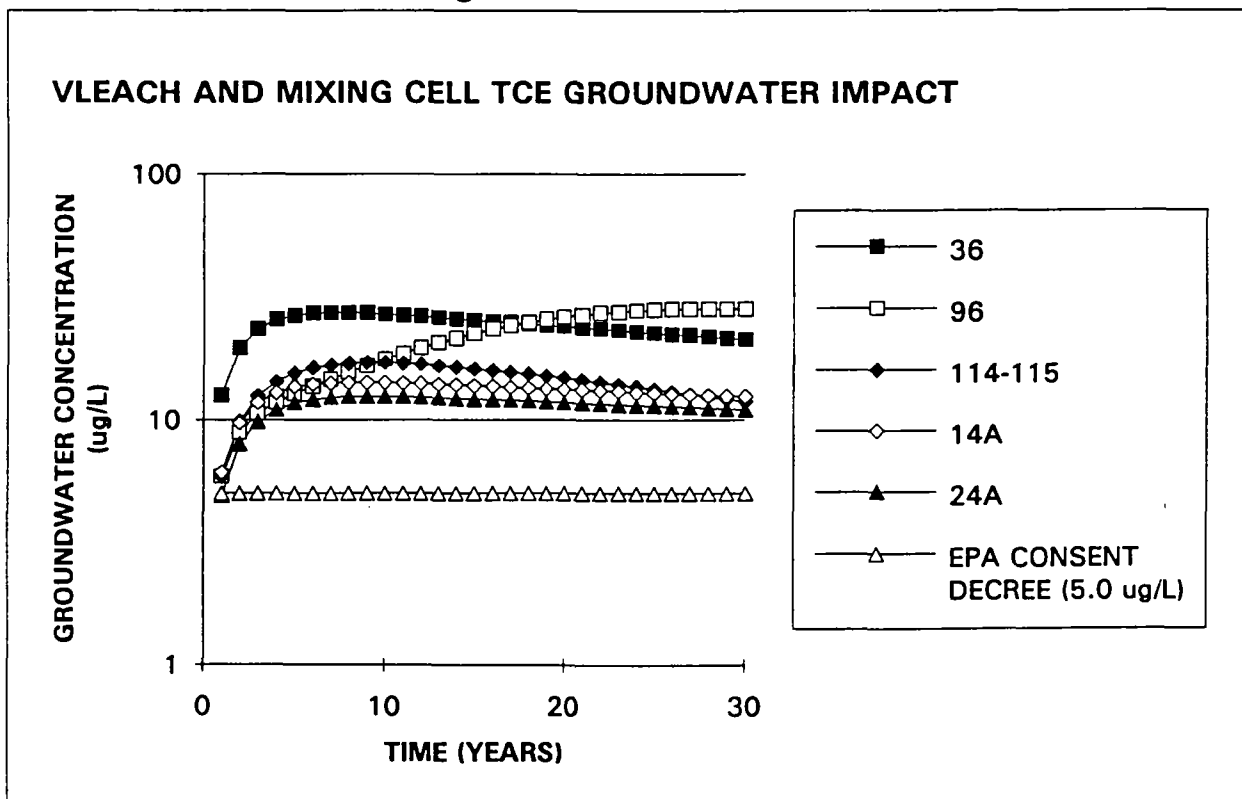


Figure 2-13 a

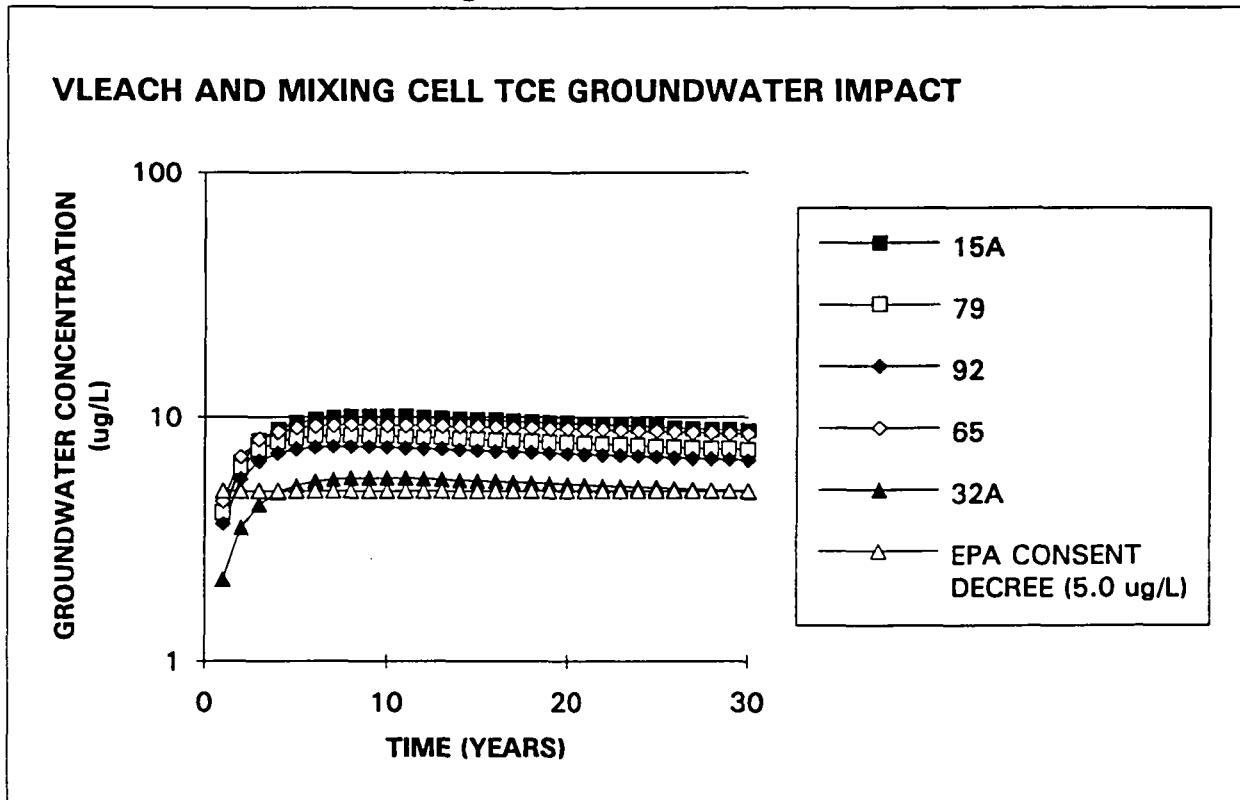


Figure 2-13 b

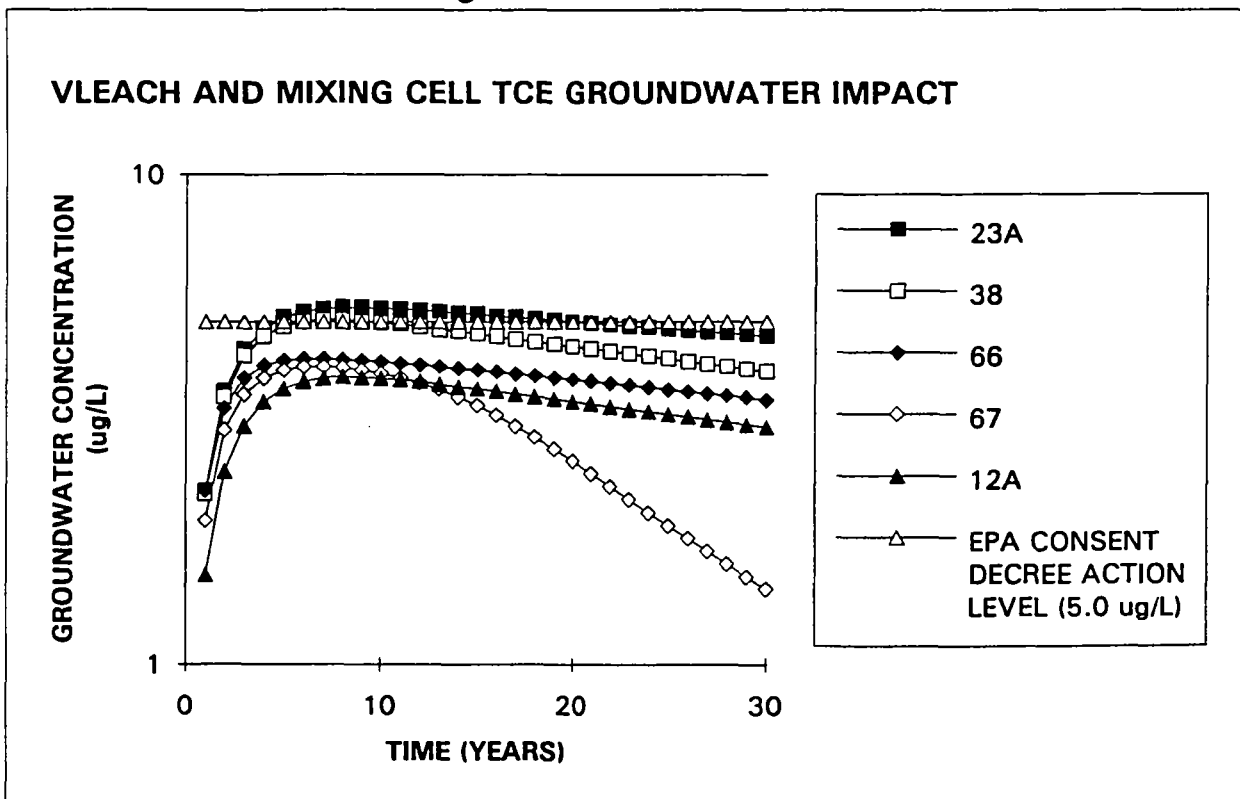


Figure 2-14 a

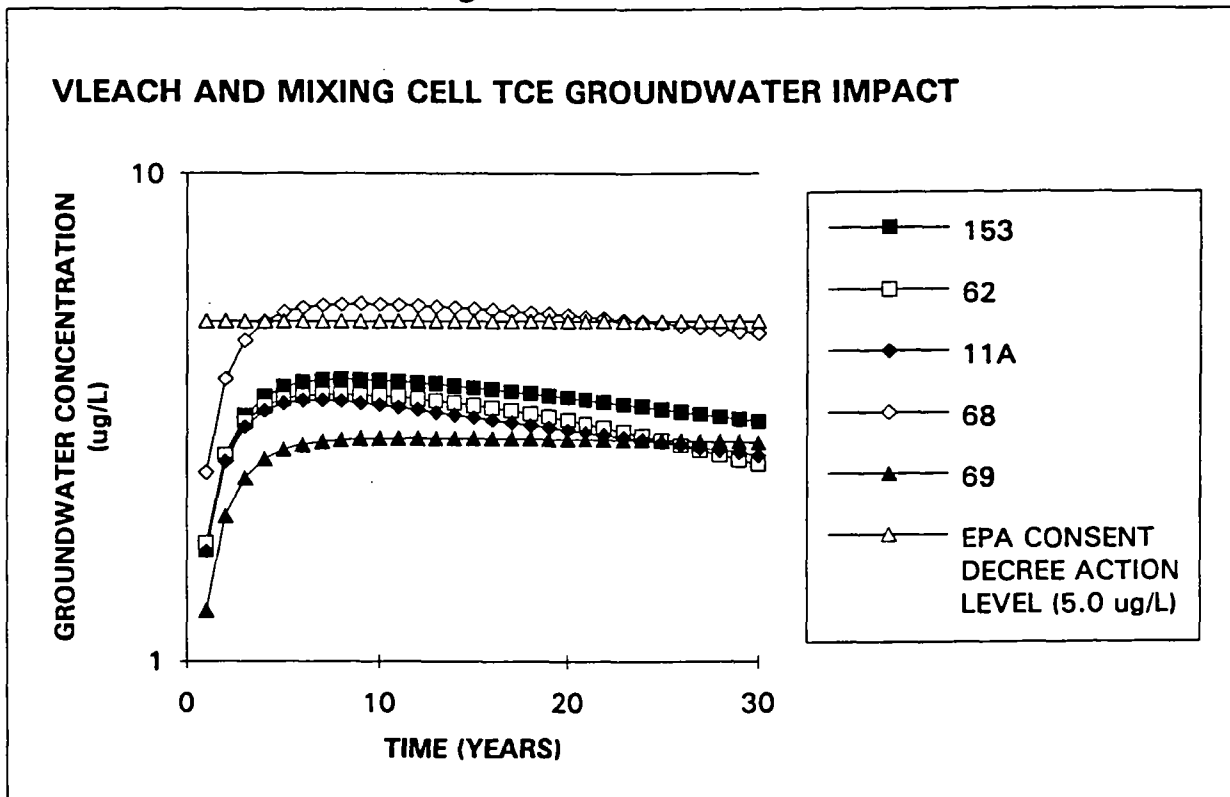


Figure 2-14 b

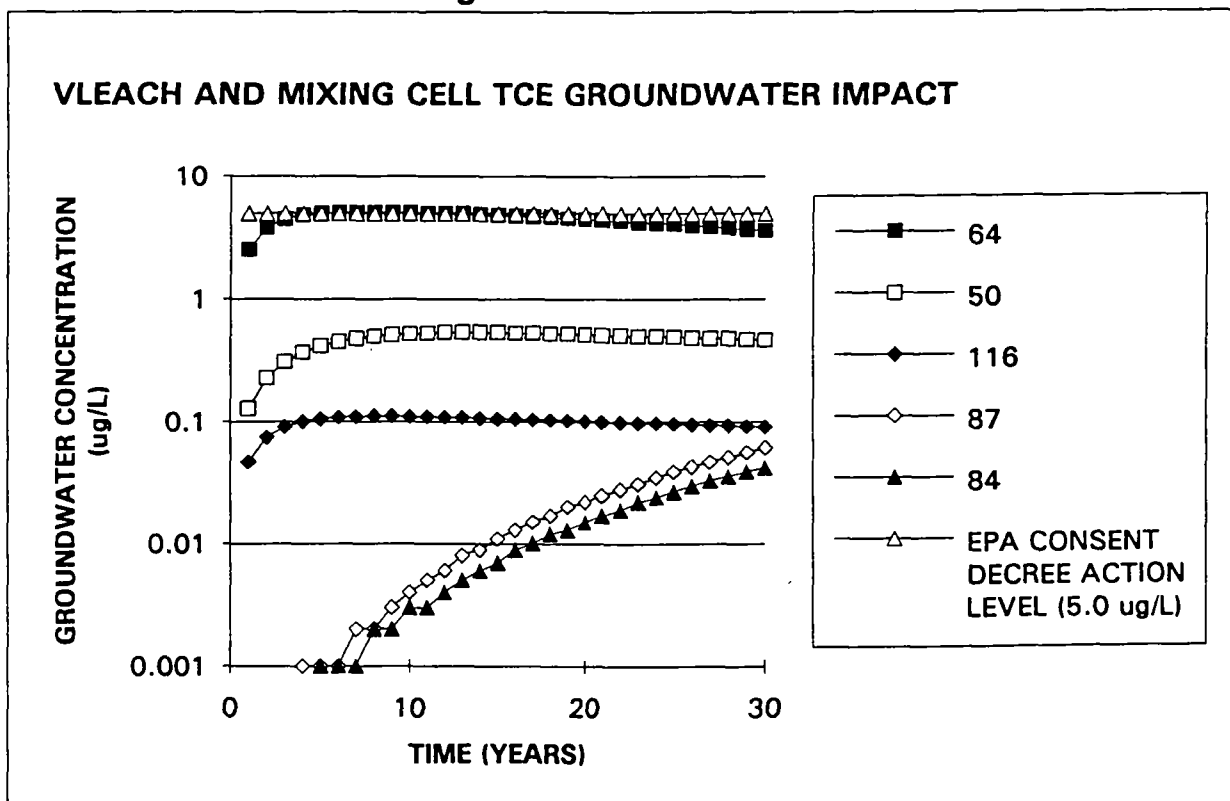
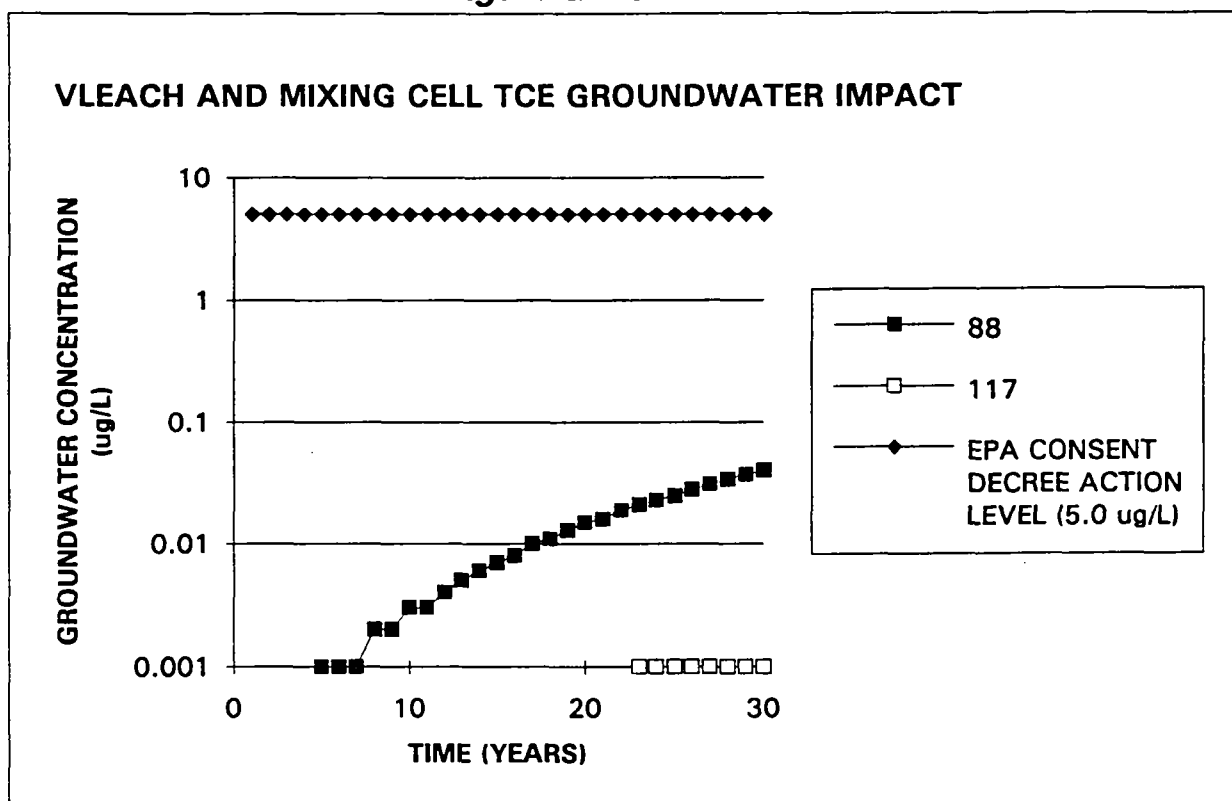


Figure 2-15



magnitude of soil vapor concentrations in non-investigated polygons within sub-area 16-EP2 is expected to be much lower than the Appendix S, RI/FS, 1989 data indicate. For instance, it is important to note that Phase II, 1992 soil vapor concentrations from the shallowest soil gas wells (approximately 16 feet below grade) in polygons 116 and 117 were two orders of magnitude less than soil vapor probe concentrations determined during the 1989 RI/FS soil vapor investigation. If this trend of lower than anticipated soil vapor concentrations in sub-area 16-EP2 polygons exists over the entire 16-EP2 sub-areas, it is likely that the majority of these presently "failing" polygons will likely pass rescreening efforts following Phase I/Phase II field investigations.

The polygons failing the VLEACH modeling that have not been investigated in accordance with the SVE Design Memorandum are prioritized in Section 2.3 for further Phase I/II investigation and VLEACH screening.

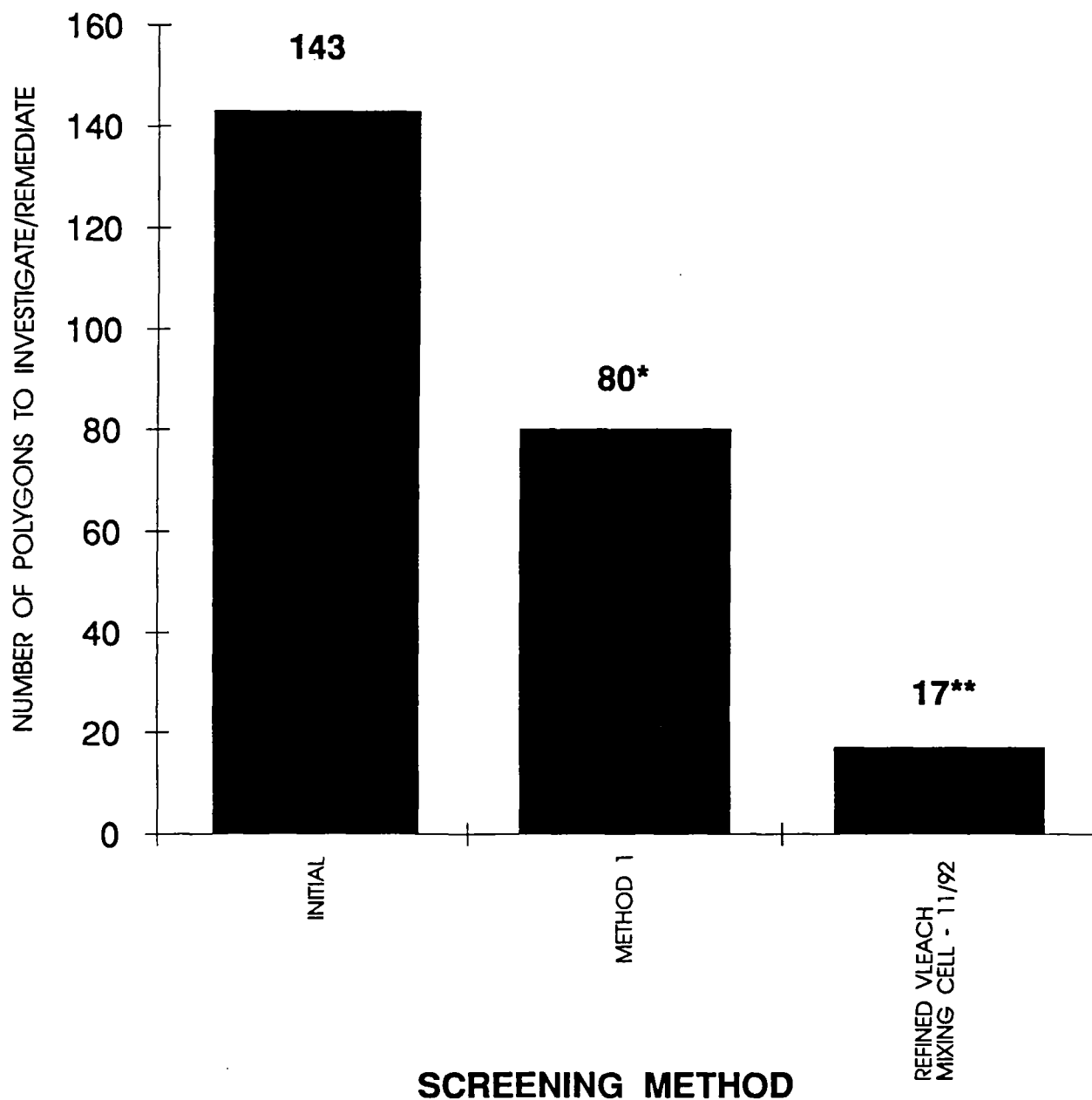
2.3 POLYGON PRIORITIZATION

The initial polygon prioritization effort described in the May, 1992 SVE Design Memorandum was designed to focus the Phase I/Phase II field investigation on the first four polygons assumed through screening to present the greatest threat to the Subunit A ground water. As part of this screening process conducted in May of 1992, initially 143 polygons underwent a conservative total mass dissolution test Screening Method #1: see Section 2.2.3.1 of May 1992 Design Memorandum) which resulted in 63 polygons passing (resultant Subunit A ground water TCE concentrations less than 5 $\mu\text{g/L}$) and 79 polygons failing (TCE ground water concentrations greater than or equal to 5 $\mu\text{g/L}$). These 79 polygons were then initially screened using VLEACH and Mixing Cell in May 1992 which resulted in 14 polygons failing the combined screening by raising Subunit A TCE ground water concentrations above 5 $\mu\text{g/L}$ over a 100 year time frame. These 14 failing polygons were prioritized in terms of threat posed to Subunit A ground water and classified as Class 2 polygons, while the remaining 66 polygons were classified as Class 1 polygons. The four Class 2 polygons that ranked highest on the prioritization list (Table 2-4 and 2-5 of the May, 1992 Design Memorandum) were scheduled for Phase I/Phase II investigation and potential SVE remediation as the operable unit remedy.

Following completion of the Phase I/Phase II investigation, new soil physical data and soil vapor chemical data was collected and applied to 32 of the 79 polygons (see Section 2.2 of this document) that had failed the conservative Screening Method #1. The approach towards using the Phase I/Phase II investigation data is described in Section 2.2. Appendix I contains the calculation tables, raw data, and results of the refined VLEACH and Mixing Cell screening of the 32 polygons.

Figure 2-16 presents a bar graph summarizing the polygon prioritization results using Screening Method #1 and VLEACH/Mixing Cell from May, 1992 to September, 1992. As is shown in this figure, the results of the refined VLEACH/Mixing Cell screening indicate that seventeen (17) polygons failed by contributing to Subunit A ground water TCE concentrations greater than 5 $\mu\text{g/L}$. Table 2-17 presents the prioritized results of the VLEACH and Mixing Cell screening based on impact to Subunit A ground water. Table 2-17 also indicates the nine polygons scheduled for Phase I/II investigation. Nine of the highest-ranked polygons have been prioritized for subsequent Phase I/II field investigation and VLEACH/Mixing Cell screening.

Once the Phase I/II investigation has been completed on the nine polygons listed in Table 2-17, the remaining 47 of the 79 polygons failing the initial Screening Method #1 will undergo complete rescreening using VLEACH and Mixing Cell as described in the preceding sections. It is not anticipated that any of the polygons to be rescreened will fail by contributing to Subunit A ground water TCE concentrations greater than 5 $\mu\text{g/L}$. This will likely be the case because the 32 polygons that were screened as presented in the preceding sections were originally the 32 highest prioritized polygons based on earlier screening efforts. In the event that any of the remaining 47 polygons do fail rescreening, the prioritization list will be revised and submitted to the U.S. EPA for review and comment. The proposed Phase I investigation will consist of initially investigating these nine Class 2 polygons using a horizontal soil vapor survey. Due to concerns regarding the effects of the site caliche layer on shallow soil vapor detection, the Phase I investigation has been expanded to collect soil vapor samples from above and below the caliche layer in polygons to be investigated. This procedure is described in greater detail in Section 4. This data would then be used to initiate Phase II activities which includes soil borings and a vertical soil vapor survey (Section 5).



* = 79 AS OPPOSED TO 80 POLYGONS FAILED AS POLYGON 27 IS CONSIDERED A SUBSET OF COMBINED POLYGON 26-29, 32-35.

** = PENDING COMPLETION OF VLEACH AND MIXING CELL SCREENING OF THE REMAINING 47 OF THE 79 POLYGONS.

SUMMARY OF POLYGON PRIORITIZATION ANALYSES		
M&E Metcalf & Eddy		
Drawn by: J. Weidmann	Job Number: 006791	Date: November 1992
Checked by: S. Zachary		Figure Number: 2-16

TABLE 2-17

**Phase I/Phase II Refined VLEACH and Mixing Cell
Polygon Reprioritization**

POLYGON DESIGNATION	MAXIMUM GROUNDWATER CONCENTRATION (ug/L)	POLYGON RANK	Course of Action
21A, 26A	106.796	1	*
113	80.883	2	*
13A	42.861	3	*
111	40.863	4	*
41-43, 8A-10A	30.514	5	**
36	27.525	6	*
96	24.893	7	*
114-115	17.156	8	**
14A	14.275	9	**
24A	12.534	10	**
15A	10.018	11	*
79	8.398	12	-
92	7.571	13	-
65	5.67	14	*
32A	5.655	15	**
23A	5.343	16	**
38	5.045	17	*
66	4.203	18	-
67	4.053	19	-
12A	3.862	20	-
153	3.802	21	-
62	3.543	22	-
11A	3.446	23	-
68	2.941	24	-
69	2.879	25	-
64	2.799	26	-
50	1.845	27	-
116	0.111	28	-
87	0.061	29	-
84	0.042	30	-
88	0.04	31	-
117	0.001	32	-

EXPLANATION

* = Polygon to undergo Phase I/II Investigation

** = Polygon tcontiguous to investigated polygon to undergo VLEACH/MIXING CELL screening using Phase I/II vertical distribution

- = No Required Action

SECTION THREE

SOIL VAPOR EXTRACTION OPERABLE UNIT DESIGN

Metcalf & Eddy, Inc. has prepared the Soil Vapor Extraction (SVE) operable unit design in conformance with Section VII-D, Subsections 8a-8j of the 1990 Consent Decree. The SVE operable unit design takes into account the extraction, conveyance, treatment, and discharge of TCE and related solvent vapors present in the site vadose zone from a single sub-area of the site. Sub-area is defined here as a polygon with numerous soil vapor extraction wells. Once the polygon commences SVE operable unit operations, sub-area is redefined in the 1990 Consent Decree as that area treated by a single operating SVE well. The SVE operable unit has been designed to treat Polygon 79 in its entirety at the same time.

The system design is broken down into six (6) primary sub-sections which include:

- Soil Vapor Extraction and Monitoring Wells
- Extraction Well Header and Lateral Piping
- Operable Unit Blower and Filtration
- Operable Unit System Vapor Treatment
- Electrical Controls and Connections
- Operable Unit Treatment Area and Security

Each of these major design areas are described briefly below. Detailed SVE operable unit Drawings and Specifications are provided in Appendix K, Draft Plans and Specifications of this Report.

3.1 SOIL VAPOR EXTRACTION AND MONITORING WELLS

The soil vapor extraction operable unit wells for vadose zone treatment were designed to account for the variable soil texture conditions present in the site vadose zone. The upper thirty-five feet of the vadose zone is characterized by fine-grained silts and sands with some clay. These soils contain air conductivities of 1×10^{-6} cm/second as determined by the physical soil laboratory analyses (Appendix J). The lower twenty-five (25) to thirty (30) feet of vadose zone is characterized by coarse sands and

gravels that contain air conductivities on the order of 1×10^{-4} cm/sec. Due to the different permeabilities, different well operation conditions will exist in the two soil matrices. To accommodate the different soil types in the vadose zone, a dual-well/single borehole design was specified. See Appendix K, Drawing M-2, Detail 6.

The dual well will allow for the independent flow and vacuum regulation of extracted vapor from the upper fine and lower coarse vadose zone areas as needed. The zone containing the most contaminant vapors will be operated with a priority. This configuration is preferred to a single fully-penetrating well because the fully-penetrating well will preferentially draw soil vapors from the lower coarse vadose zone, and significantly reduce the effective induced vacuum in the upper fine vadose zone. This configuration will also provide for improved vertical distribution of vapor flow control over the entire sub-area and will allow for more direct treatment of productive or resistant soil horizons.

The dual extraction well design requires the installation of a twelve (12) inch diameter boring to a depth of approximately fifty-five (55) feet below grade. The boring will be advanced through the use of a hollow stem auger, cable tool, or air rotary rig. The drilling of the well will use no fluids with the exception of air to prevent vadose zone formation clogging. Once the boring has been advanced to the total depth, the drilling casing will temporarily remain in place while the extraction well is constructed. Table 3-1 illustrates the SVE operable unit well parameters. Drawing M-2, Detail 6 illustrates the construction of the soil vapor extraction well.

Prior to well construction, the bottom of the borehole will be sealed to prevent a direct conduit for ground water/capillary water to migrate to the extraction well. The borehole bottom will be sealed with a six (6) inch lift of Wyoming 8-12 sieve bentonite crumbles. The bentonite will be hydrated in place via a 3/4" tremmie pipe by 1.0 gallon of de-ionized water. Once the seal is fully hydrated, the lower extraction well will be constructed.

The lower extraction well screen will extend from 30 to approximately 60 feet below ground surface (b.g.s.). Should the capillary fringe be encountered at a depth of less than 60 feet, the well screen will be shortened so that it does not extend into the capillary fringe. As specified in Table 3-1, three

TABLE 3-1

SOIL VAPOR EXTRACTION WELL PARAMETERS

Well Boring Depth	50-55 feet
Well Boring Diameter	12 inches
Well Drilling Method	Hollow stem, air rotary or cable tool
Well Screen	3" Dia., Sch 40 PVC, flush thread, 0.02" Machine slot
Deep Well Screen Depth	30-55 feet b.g.s.
Shallow Well Screen Depth	0-25 feet b.g.s.
Screen Gravel Pack	Colorado 8-12 silica or 3/8" washed round pea stone
Bottom Hole Seal	8-12 Wyoming bentonite crumbles, (8-12 sieve) 6 inches min.
Well Sand Seal	Colorado #30 sand, 1.0 foot (or equivalent)
Well Annular Seal	Wyoming 8-12 bentonite crumbles, min. 1.5 feet placed and hydrated in 6" lifts.
Annular Seal to Road Box	Portland neat cement with 5% powder volclay.
Road Box	36" by 36" steel vault w/hinge lid, H-20 rating.
Road Box Completion	Concrete aggregate, 3000 psi commercial, no additives, slope apron to grade.
Well Head Connections	3" Dia, Sch. 40/80 PVC fittings, true-union Ball valves, socket connection
Well Instrumentation	2-3/8", 2-1/4", 1-3/4" compression fittings for flow, pressure, concentration measurement

(3) inch diameter, Schedule 40 PVC well materials will be used. All joints will be flush threaded and the screen will be machine slotted with 0.02 inch openings. The remainder of the well to grade will consist of Schedule 40 PVC casing.

The well gravel pack will consist of Colorado 8-12 sieve silica sand or 3/8" washed round pea stone to one (1) foot above the screen top. While the gravel pack is in place, the drilling casing will be pulled to ensure a competent gravel pack and minimize vadose zone cave in. A one (1) foot sand seal of Colorado #30 silica sand will be placed on top of the 8-12 silica to prevent the bentonite seal from being drawn into the 8-12 silica under extraction operations. If 3/8" washed pea stone is used, the

sand seal will not be used, and two additional six (6) inch lifts of Wyoming 8-12 bentonite crumbles will be installed, each hydrated with deionized water using by a 3/4" tremmie pipe.

A bentonite seal will then be placed in the boring to seal the lower extraction well. The bentonite seal will consist of a minimum 1.5 feet of Wyoming 8-12 sieve bentonite crumbles placed and hydrated in six (6) inch lifts. Each lift will be checked for proper moisture content with a tape. Water addition will be adjusted in the field as necessary.

The shallow SVE well will be constructed in the exact same manner as the lower well. The screened portion of the shallow SVE well will extend from approximately 10 to 25 feet b.g.s. Once the bentonite seal has been placed, the ground around the extraction well will be prepared for well head completion. Three possible well head completions are illustrated in Appendix K, Drawing M-2, Details 5, 6, and 11. Two of the completions are above ground and one of the completions is vaulted below ground. Polygon 79 utilizes two for the completion methods as illustrated in Appendix K, Drawing C-1.

Roadway vault completion will consist of excavating around the SVE well to a depth of 2'-9". Drawing M-1, Details 3, 4, and 9 illustrate the construction configuration of the well vault. Once the excavation is complete, the base of the excavation will be compacted to 95% for a total of 3". After the base has been compacted, the well vault will be set. The cover of the vault should be approximately 1" above grade for surface water drainage. Following well vault placement, the excavated dirt should be placed and compacted as indicated on Drawing M-1, Detail 4. The final concrete apron should be poured and worked to slope away from the vault outer lip for surface water drainage diversion. A 3000 psi commercial mix, no-additive concrete should be used. Prior to backfilling and concrete installation, the four (4) inch diameter well header should be terminated and capped inside the well vault. Above ground completion will involve sealing the ground surface with the well casing to prevent water infiltration, then connecting the above ground SVE header to the extraction well. (See Appendix K, Drawing M-2, Detail 5).

Connection of the deep and shallow extraction wells to the four (4) inch header will be accomplished through the use of three (3) inch diameter Schedule 40 or 80 PVC fittings. Drawing M-2, Details 6 and 5, and Drawing M-3, Detail 8 illustrate the connection of the SVE wells to the well header. A valve has been installed in the bottom of the four inch header for condensate drainage for vaulted installations. All system piping is sloped at approximately 2% (0.02 feet per foot) toward the extraction wells so that any collected water from condensation inside the piping during periods of shut-down will automatically drain back to the extraction well. In the event that a subsurface vault is not required for well head completion, the well can be connected to the system header above ground. Drawing M-2, Details 5 and 9 illustrate the above-ground SVE well construction. Appendix B, Draft SVE Sub-Area/Well Operation and Maintenance Manual contains detailed information on the operation and maintenance of the SVE wells.

3.2 EXTRACTION WELL PIPING

Each of the soil vapor extraction well pairs is connected to the soil vapor extraction operable unit by a main six (6) inch Schedule 40 or 80 PVC header and it's associated laterals. This header and lateral network will be buried a minimum of twenty (20) inches below grade in areas where the piping cannot be placed at the surface. In areas where the pipe can be installed above grade, it will be mounted on unistrut, concrete, or equivalent supports. See Drawing M-3, Details 10, 13, and 18, and Drawing M-4, Detail 19.

All piping, both above and below ground will be installed to slope to the extraction wells at 0.02 feet per foot, or 2%. The pipe header and laterals will are designed and installed to operate under a continuous condition of 16 inches of mercury (Hg) vacuum and a flow rate of 500 scfm.

Installation of the PVC pipe will be in accordance with the pipe manufacturer's guidelines. The pipe will be installed within trenches as illustrated in Drawing M-3, Detail 9. All PVC pipe will be bell-ended and will be solvent welded in the field. Ratchet straps will be used to be sure that all solvent-welded joints are tight and do not separate during cement curing. Prior to cementing, two coats of primer will be applied to the PVC joints to assure quality solvent welds. Once the piping has been

welded, the ends will be sealed after a minimum of six (6) hours and the piping will be vacuum tested. Once the vacuum test is confirmed, the piping in the trenches will be backfilled with native material in lifts and compacted to 90 to 95 percent. See Drawing M-3, Detail 9.

Where piping will be placed above ground, the pipe will be supported and sloped through the use of unistrut or concrete (or equivalent) supports. The PVC pipe will be secured to the supports through the use of pipe straps and unistrut channels. See Drawing M-3, Detail 10 and Drawing M-4, Detail 19.

Flange connections at isolation valves and at the treatment system connection will be made through the use of PVC-steel ring van-stone flanges. These flanges will allow for a strong piping connection of PVC pipe with steel pipe and valves. See Drawing M-3, Detail 12.

3.3 OPERABLE UNIT BLOWER AND FILTRATION

The soil vapor extraction system blower provides the pressure differential in the vadose zone to induce solvent vapor migration and removal. The blower is connected to the extraction wells and treatment system through a network of piping and is controlled by the electrical control system.

The vacuum blower specified for the SVE operable unit is of the positive displacement type. This type of blower provides a wide range of flow rates and vacuums for a given motor size. Table 3-2 contains the design specifications for the SVE operable unit vacuum blower.

The blower flow rate has been sized to operate at 500 scfm at a vacuum of 15 inches of mercury vacuum. Flow rates of up to 750 scfm are possible with the given motor and blower body at lower applied vacuums and higher blower speeds. The higher blower speeds can be accomplished through the use of different size blower sheaves.

TABLE 3-2

SVE OPERABLE UNIT VACUUM BLOWER SPECIFICATIONS

Type	Positive displacement, dual rotating lobes, continuous duty
Flow Rate	500 scfm
Vacuum Rating	15 inches mercury (Hg)
Horsepower	30
Electrical Requirement	480 Volt, 3 phase, 60 amp
Blower Speed	1500 RPM
Discharge Pressure	2 psi
Noise Attenuation	Discharge silencer, enclosure
Temperature Rise	120°F
Lubrication	Oil bath
Mounting	Steel channel skid
Plumbing	6 inch dia. piping w/150 lb. flange connections, inlet and discharge
Motor Protection	Motor overload circuit, vacuum relief valve

Due to the heat generation during blower operation, the discharge air can exceed 200°F in the summer months. As a result of this discharge temperature, the vapor-phase granular activated carbon (GAC) treatment beds have been placed on the vacuum side of the blower. This design takes advantage of the higher GAC removal efficiency at lower temperatures. Drawings M-1, Detail 1, and Drawings E-2 and E-3 illustrate the location of the blower with respect to the entire operable unit.

Flow and vacuum are generated by the blower by two rotating lobes within the blower body. Tolerances for the meshing steel lobes are very close, therefore high efficiency particulate filtration is necessary upstream of the blower intake. A high efficiency particulate filter has been placed at the intake of the blower. The filter consists of a paper element within a wire mesh basket. The filter element is housed within a steel vacuum-rated housing. The steel filter housing is rated to 29 inches mercury ("Hg) vacuum and has a removable lid for filter element cleaning and changeout. See Appendix A for the SVE operable unit Operation and Maintenance Manual for filter maintenance. A differential pressure indicator is placed across the filter to determine when to clean the filter. The differential pressure indicator has a range of 0 to 50 inches of water differential pressure. Filter service will be conducted when the differential pressure exceeds 25 inches of differential water pressure.

The blower head is driven by a 30 horsepower, electric motor linked to the blower via a belt drive. Electrical requirements for the blower are: 480 volt AC; three phase, and 40 amp current. The motor is protected from electrical overload by a motor process overload protection circuit. The motor is also protected from overload in the event of system blockage by a vacuum relief valve located within the blower cabinet. The vacuum relief valve is set to release at a vacuum of greater than 15 inches mercury and will allow the full flow rate of 500 scfm to pass through the relief valve.

A primary blower electrical interlock is provided to prevent system start-up when certain alarm conditions are present. The blower lockout conditions include:

- Low flow from SVE wells and header system (time delay)
- High-High water level in air/water separator
- High-High water level in water storage tank
- Blower motor overload
- Telemetry signal

The blower can only be started or re-started once these safety interlocks have been corrected and the manual reset for the blower is activated.

Instrumentation for blower monitoring includes:

Flow	Upstream of blower prior to particulate filter (FE/FSL 07).
Pressure	Differential Pressure Indicator on particulate filter (pre-carbon filter (DPI 23), pre-blower filter (DPI 22). Indicator at blower inlet (PI 16). Indicator at blower discharge (PI 20).
Temperature	Indicator at blower inlet (TE 17). Indicator at blower exhaust (TI 21).
Concentration	Indicator at Primary Carbon exhaust (AE 11). Indicator upstream of dilution air connection (AE 08).

The pre-blower temperature indicators, the motor protection circuit, and the contaminant vapor analyzer outputs are wired to the telemetry unit and programmable logic control unit (PLC). Drawing E-3 illustrates the blower skid instrumentation. All of the instrumentation and control inputs are digital, indicating a go/stop status with the exception of the vapor concentration, the blower air inlet temperature, and inlet air flow, which are analog. The analog output will be variable depending upon weather and operational conditions, and therefore requires a continuous readout.

Automatic blower shutdown will occur under the following conditions:

- Low air flow from SVE wells and header system (time basis)
- High-High water level in air/water separator
- High-High water level in water storage tank
- Blower motor overload

In addition to the automatic blower shutdown conditions, the blower can be shut down remotely via telephone lines and computer link to the treatment system through the telemetry/PLC unit. Once the system is shut down, manual reset at the system control panel is required as a safety feature.

Once the vapor has passed through the blower, system noise is attenuated by a discharge silencer. Noise levels for the blower under full load (500 scfm and 15" Hg) is expected to be on the order of

60 decibels at 5 feet from the unit. The noise levels will decline exponentially with distance from the unit. Vapors exiting the silencer are then discharged to the atmosphere through the operable unit stack (See Drawing M-1, Detail 1 and Drawing E-3). The stack will contain a sump at the base to allow for the collection of any condensed water. The sump contains a drain valve that allow for periodic draining and maintenance. Little to no water is expected to collect in the sump, therefor no automatic controls are provided. To prevent water from entering the stack when the system is not in operation, a hinged cap has been placed at the stack outlet. When the system is in operation, the cap is pushed up by the exiting air stream. When the system stops, the loss of air flow causes the cap to fall and rest on the top of the stack, preventing water entry.

All of the components for the blower are illustrated in Drawing E-3 with the exception of the discharge stack and sump, which will be mounted on a carbon steel box-tube skid. The box-tube skid will contain forklift or crane lifting points for easy moving. The box-tube skid will be mounted on a concrete pad to prevent movement from operational vibrations. A chain link fence will be constructed around the concrete pad and treatment area to provide system security and safety. See Drawing M-1, Detail 1.

3.4 OPERABLE UNIT VAPOR TREATMENT

Vapor extracted from the vadose zone will be laden with solvent vapor in concentrations that are expected not to exceed 2,500 ppmV. Prior to the vapors being exhausted to the atmosphere, 90% or more of the solvent constituents will be removed. Two principal methods of removing solvent vapors from air streams are oxidation and adsorption. Adsorption was the selected treatment technology based on the expected low concentrations of solvents extracted from the sub-surface. Oxidation is an effective treatment alternative, however if the solvent concentrations do not exceed 3,500 ppmV for a large portion of the project, the cost for auxiliary fuel such as methane to maintain a minimum oxidation temperature becomes excessive.

Two types of solvent adsorption systems were evaluated for use as the operable unit treatment. The two adsorption systems were on-site regeneration and off-site regeneration. Due to the very high

capital and operation costs of the on-site regeneration system, the off-site regeneration system was selected. Additionally, the on-site regeneration system requires more complex controls and electrical connections which limits the ability of the system to be easily moved from one polygon to another.

The off-site regeneration system utilizes vapor-phase granular activated carbon (GAC) as the adsorption media. As solvent vapors pass through the GAC bed, they are molecularly attracted to the large surface area of the GAC and removed from the air stream. Site-specific vapor phase GAC efficiencies range from 1 to 15 percent with an average of 4 percent by weight. This translates to 4 pounds of solvent adsorbed per 100 pounds of GAC. Factors affecting the efficiency of GAC solvent removal include vapor velocity, residence time, vapor temperature, and vapor relative humidity. Because adsorption of solvents onto GAC is an exothermic process, the temperature of the air stream affects the carbon efficiency most dramatically. Due to this fact, the carbon beds have been located at the inlet side of the blower rather than the exhaust side of the blower where discharge temperatures can exceed 200°F.

As solvent vapors pass through the GAC bed, they are adsorbed by the carbon nearest the bed inlet. As the adsorption process continues, the GAC at the bed inlet becomes fully loaded and the front of active adsorption moves through the GAC bed in the direction of vapor flow. When the front of active adsorption reaches the end of the GAC bed, the vapors can then exit the GAC unit. This condition is commonly referred to as "break through". Once the GAC unit has broken through, the bed is required to be regenerated. In the case with off-site regeneration, the carbon is removed from the GAC bed by vacuum truck and hauled off site for thermal regeneration by a licensed facility. Once all of the "spent" carbon has been removed, new carbon is placed in the GAC bed and the GAC bed can be placed back on line.

Due to the process condition of break-through, two GAC beds have been placed in the system design. The first bed, termed the primary bed, does the active adsorption. Effluent from the primary bed then passes through a second carbon bed, termed the secondary GAC bed. The secondary GAC bed is used as a precautionary measure against direct discharges of solvent-laden air to the atmosphere. When the primary bed breaks through, the system is shut down and the broken-through bed is either regenerated

with new carbon or is replaced with a new carbon bed. This GAC bed changeover insures that no direct discharges of solvents to the atmosphere occur. The GAC beds will be connected to the system through the use of 6 inch diameter reinforced flexible tubing to facilitate easy and timely carbon bed changeout or regeneration. When carbon bed regeneration or changeout occurs, the bed previously in the secondary position will be moved to the primary position, and the new bed will be placed in the secondary position. This changeout protocol maximizes the efficiency of the carbon and is facilitated by the flexible tubing.

Carbon utilization and changeout frequency were estimated based on data presented in the RI/FS, Appendix S (Volume VI), June 7, 1989.

3.4.1 Carbon Efficiency Calculations

Calculation 3-1 shows that under the highest solvent loading conditions of 920 mg/l TCE, 70 µg/l DCE, and 100 percent relative humidity, each 2,000/lb carbon canister would adsorb about 147 pounds of solvent; however, lower relative humidity would result in improved carbon performance.

As the concentrations of solvent decrease, carbon adsorption efficiency, or utilization, will decrease. Thus, an adsorbance efficiency of 50 percent was assumed for predicting carbon utilization for the project duration. Assuming 90 percent solvent recovery, with 200 lb solvent in the polygon, two carbon changeouts are required as shown in Calculation 3-1. It was estimated that the removal of 200 lbs. of VOCs from Polygon 79 will result in soil vapor concentrations below the allowable residual mass (ARM) for the polygon to pass VLEACH screening (See Appendix B).

CALCULATION 3-1 CARBON UTILIZATION AND CHANGEOUT FREQUENCY

1. Purpose: Estimate the carbon utilization

2. Basis: Per 6/7/89 RI/FS; Appendix S (Volume VI)

- DCE = 70 $\mu\text{g}/\ell$
- TCE = 920 $\mu\text{g}/\ell$
- 500 scfm extraction rate w/2,000/b-carbons upstream of blower, per 9/10/92
- 100% RH
- Carbon performance per Figures 43 and 44 of the RI/FS, Appendix S

3. Assume:

- 100% RH reduces performance by factor of 2
- Carbon bed temp is 105°F (design temp)

TCE adsorption (820 $\mu\text{g}/\ell$) = 20% @ 77°F
15% @ 105°F
11% @ 140°F

DCE adsorption (70 $\mu\text{g}/\ell$) = 8% @ 77°F
6% @ 105°F
3% @ 140°F

Adjusting for RH at 105°F (for design calc)

TCE adsorption = 7.5%
DCE adsorption = 3.0

Then @ 500 scfm:

$$lb^l_{emitted} = Conc_i \frac{\mu}{\ell} \times \frac{28.32\ell}{ft^3} \times \frac{500 ft^3}{min} \times \frac{60 min}{hr} \times \frac{24 hr}{day} \times \frac{1 gm}{1,000,000 mug} \times \frac{1 lb}{453.6 gm}$$

$$for TCE = \frac{920 \times 28.32 \times 500 \times 60 \times 24}{1,000,000 \times 453.6} = 41.4 \frac{lb}{day} TCE extracted$$

@ 7.5% carbon efficiency = 550 lb carbon used per day

$$\text{for DCE} = \frac{70 \times 28.32 \times 500 \times 60 \times 24}{1,000,000 \times 453.6} = \frac{3.15 \text{ lb}}{\text{day}} \text{ DCE extracted}$$

@ 3% carbon efficiency = 105 lb carbon used per day

Total initial system carbon usage is 605 lb carbon/day.

Then:

2000 lbs of carbon would initially last 3.3 days @ constant extraction of 920 $\mu\text{g}/\ell$ TCE and 70 $\mu\text{g}/\ell$ DCE and 500 scfm.

Note:

Per Tables 5 and 6 of the SVE Pilot Test (RI/FS; Appendix S, Volume VI, 1989), other constituents CHCl_3 , TCA, CCl_4 and PCE were not present in sufficient concentrations to affect carbon usage.

Based on a log-normal decline of VOC concentrations and 90% removal in one year for 200 lb total polygon mass, each 2,000 lb. carbon bed can adsorb (initially) 10.4 lb DCE, 136.6 lb TCE, or 147 lb total solvent per carbon canister.

As inlet solvent concentrations decrease, carbon effectiveness decreases. Visually extrapolating from adsorption isotherms in Appendix S of the RI/FS (1989) for TCE and DCE adsorption, assume a factor of 2 loss of effectiveness.

Then:

73.5 lb. total solvent is adsorbed per 200 lb. carbon bed.

Based on the plots shown and assuming 200 lbs. of solvent in the polygon treated:

200 lb Total Solvent Removal from Polygon 79

Month	Recovered Solvent	Changes*
1	40	0
2	30	0
3	20	1
4	20	0
5	15	0
6	15	0
7	10	1
8	9	0
9	7	0
10	6	0
11	5	0
12	4	0

*not including the initial carbon supplied with the operable unit.

3.4.2 Carbon Efficiencies

As discussed previously, two in-series activated carbon beds for VOC emissions were tested during the extraction pilot test (Appendix S, RI/FS, 1989). Each bed contained 200 lbs of Calgon BPL, 4x6 mesh carbon. The intake and exhaust VOC concentrations for each canister were sampled and analyzed during each of the tests. In the first 3 tests (SVE-B, WO901, and WO903), however, sampling of the canister was not performed before breakthrough had occurred. Therefore, little information was gained during these tests to evaluate carbon efficiencies and capacities. During the final test, at SVE-A, precautions were taken so that breakthrough was not missed. Following replacement of the activated carbon with fresh carbon, samples were collected after the first carbon canister and at the extraction well head between every 1 to 2 hours.

A plot of the carbon outlet concentration versus time for both TCE and 1,1 DCE is shown in Figure 40 (RI/FS, Appendix S, 1989). The average inlet concentrations of TCE and 1,1 DCE during

this time period were $920 \mu\text{g}/\ell$, respectively. The average flow rate was approximately 222 scfm at a carbon inlet temperature of 185°F . Graphs of the percent carbon efficiency (equal to the outlet concentration divided by the inlet concentration in percent) versus the percent carbon capacity (equal to the VOC mass divided by the mass of carbon in percent) for TCE and 1,1, DCE is provided in Figures 41 and 42, respectively of Appendix S (RI/FS, 1989). Break through of TCE began at a carbon capacity of less than 5%. This is equivalent to 100 lbs of carbon required to trap 5 lbs of TCE. Based on the RI/FS pilot testing results, and the above five presented calculations, the SVE operable unit carbon beds were sized accordingly.

The specifications of the primary and secondary GAC beds are identical and are detailed in Table 3-3.

The carbon adsorption system is designed to operate remotely with little maintenance. Drawing M-1, Detail 1 and Drawing E-2 illustrate the GAC beds and system connection. Drawing M-1, Detail 1 illustrates the configuration of the system components in the treatment compound. To insure that the treatment system is attaining the air discharge limit, a vapor analyzer has been specified to be placed between the primary and secondary GAC bed. A reading on this meter will signal the operator that the primary GAC bed has broken through and that the secondary bed is now in the adsorb mode. The operator can then shut the system down and have the broken-through GAC bed serviced or replaced.

All piping for the GAC beds will be 6 inch diameter flexible spirallite tubing or equivalent. Locations where analytical instruments, controls, or sample ports enter or exit the treatment system piping will be constructed of Schedule 80 PVC or carbon steel in short spool sections.

The shell and heads of the carbon vessels will be constructed of carbon steel with reinforcement to withstand a minimum of 16 inches of mercury vacuum. The exterior of the vessels will be painted with a white powder coat enamel to reflect heat and resist weathering, and the interior of the vessels will be coated with a fusion-bonded epoxy that will resist water and solvent degradation. The internal carbon support screens will be constructed of 316 stainless steel or functional equivalent. The screen supports will be welded directly to the vessel walls to insure vessel integrity.

TABLE 3-3
CARBON ADSORPTION BED SPECIFICATIONS

Weight of Carbon	2,000 pounds
Type of Carbon	Vapor-phase, coconut shell or bituminous, 4x8 mesh
Carbon Surface Area	1250 sq. m/g
Carbon Density	29 lb/ft ³
Vessel size	4 ft. dia, 7 ft. 3 in. high
Vessel Construction	Carbon steel shell and heads
Vessel External Coating	Powder coat enamel (white)
Vessel Internal Coating	Fusion bonded epoxy
Vessel Fittings	150 lb ANSI flanges
Internal Carbon Support Screen	316 stainless steel
Vacuum Rating	16 in. Hg.
Piping Connections	Schedule 80 PVC or carbon steel, 6 in. diameter and spiralite flexible piping.
Skid Construction	Carbon Steel, box-tube with crane and forklift points.
Vacuum Protection	Vacuum relief valve-15 in. Hg, 500 scfm

Vacuum relief valves are installed on each of the carbon beds to insure that the beds are not damaged due to excessive process vacuum should an upset condition exist. The vacuum relief is sized to release at 15 inches of mercury vacuum and will allow the full 500 scfm of air flow through the relief valve. The relief valves will be tested prior to unattended operation to insure proper operation. Drawing E-2 illustrates the location of the vacuum relief valves at the top of each of the carbon beds.

Each carbon bed will contain 2,000 pounds of 4x6 mesh activated virgin BPL-type coconut shell carbon. The carbon will have an approximate internal surface area of 1,250 square meters per gram of carbon and will have a density of approximately 29 pounds per cubic foot. The initial batch of carbon will be loaded in the vessels at the point of manufacture or at the site, depending upon supplier. Subsequent regenerations of carbon, if needed, will be conducted on site in accordance with the guidelines set forth in the Operable Unit Operation and Maintenance Manual (Appendix A). All carbon changeout or regeneration will be carried out by a licensed carbon regeneration company. Piping connections to the carbon bed will be through six (6) inch, 150 pound standard ANSI flanges. The six inch flexible piping will be connected to the beds through the use of aluminum camlock fittings with dog ties. A manual drain valve is located at the base of each vessel to permit removing any condensate that may collect in the base of the vessel.

Vapor sample ports will be installed on each of the carbon beds such that both system influent and effluent vapor can be withdrawn for laboratory chemical analysis. An automatic solvent vapor monitoring instrument will be installed between the primary and the secondary carbon beds to detect breakthrough. The instrument will read effluent concentrations in parts per million by volume (ppmV) and will be connected to the treatment system control and telemetry unit. The solvent vapor monitoring unit will not automatically shut the unit down in the event that solvent vapors are detected between the primary and secondary carbon beds, however the telemetry unit will notify the operator that service for the primary carbon unit is necessary. Depending upon the concentrations of solvent vapors exiting the primary carbon bed, the operator will have the option to shut the operable unit down via the telemetry unit.

Each of the carbon vessels will be mounted on a carbon steel box-channel skid. The skid will provide a rigid base for the vessel to sit on as well as provide a lifting point for the vessel during servicing and installation/moving. The carbon steel skid will be painted with the same white powder-coat enamel.

Once the solvent-laden vapors have passed through the carbon beds and the solvents removed, the clean air passes through the vacuum blower and is then discharged to the atmosphere through the discharge stack. See Drawing M-1, Detail 1 and Drawing E-3. The discharge stack will discharge the process air at a height of 25 feet above ground level and consists of three primary components which include: sump, silencer, and stack extension. Each of these components are described briefly below.

The sump will be installed on the stack to provide a location for any water condensate in the stack or leaking rainwater to collect for easy removal. The size of the sump will be approximately 10 gallons. The water will be clean at this location, therefore any water collected can be directly discharged to the site pad or ground. A manually-operated valve at the base of the sump provides the drainage control. See Drawing E-3. Prior to the first water discharge during system start up, the water will be screened with a field gas chromatograph to determine if the water contains any contaminants. If the water is clean, it will be discharged to the ground. If the water contains TCE, the major subsurface contaminant, the water will be reserved, temporarily stored in the water storage tank, then transferred to the Subunit A air stripping unit for treatment.

A silencer has been provided within the stack to reduce overall system operational noise. The silencer will consist of a steel shell with internal steel baffling to reduce the noise as a result of operable unit blower operation. The silencer will be mounted directly above the sump and will contain six inch diameter inlet and exhaust ports. As with the other components of the system, the inlet and exhaust ports of the silencer will contain 150 lb. ANSI flanges for rigid connection.

The remainder of the stack will consist of a six inch diameter light carbon steel riser to a total height of 25 feet above ground level. The stack riser will be bolted to the discharge silencer and will be secured

by a total of four (4) guy wires fastened at the top of the stack. The guy wires will be anchored into the ground with soil anchors or will be connected to the treatment system pad depending upon system location. The top of the stack riser will contain a weighted flapper cover to eliminate rain water from entering the stack when the system is not operational. When the system is turned on, the flapper cover will hinge upward, providing unrestricted air flow out of the stack. When the operable unit is stopped, the flapper cover will fall against the top of the stack riser automatically by gravity.

The carbon beds will require little servicing and maintenance for continuous, operation. The beds will be operated at all times in accordance with the design specifications and the manufacturers' recommendations as well as in accordance with the conditions of the Maricopa County air discharge regulations (Appendix F). As with the carbon beds, the stack will be painted white with a powder-coat enamel.

3.5 ELECTRICAL CONNECTIONS AND CONTROLS

The soil vapor extraction operable unit has been designed to operate as a continuous operatorless unit. Additionally, the operable unit has been designed to be monitored remotely via telephone lines and a telecommunication interface module. The controls of the treatment system, the safety interlocks, and the modes for operation and shut-down are described below.

3.5.1 Operable Unit Controls

Section 3.1 through 3.4 describe the process flow of the soil vapor extraction operable unit. Solvent laden air is drawn from the subsurface via a network of wells, passes through the air/water separator, filters, carbon beds, process blower, and is then discharged to the atmosphere. Automatic control of the operable unit will be provided through a main control panel that will house the programmable logic control unit (PLC) and the telemetry unit. In addition to the electrical controls, various pressure, flow, concentration, and level indicators have been specified for the operable unit for operational monitoring and compliance. Drawings E-1 through E-6 illustrate the electrical controls and logic for

the operable units. Components of the system requiring control or monitoring are illustrated in Drawings E-2 through E-4 and are described in further detail below.

3.5.1.1 Low Air Flow Switch

The low air flow switch detects the amount of air being drawn from the well header network and the air blending station. See Drawing E-2. The switch (FE/FSL 07) provides a primary interlock for system continuous operation and will stop the blower when low or no air flow is detected. The interlock for low flow from the well header or the air blending station is a safety for blower protection. The flow switch is also a flow element that allows for direct reading of the system flow rate. The low flow switch contains a time delay relay to allow for the system to build air flow during start up or system adjustment and is a redundant safety in the event that the operable unit motor protection switch and carbon bed vacuum relief valves should fail. The analog output is wired to the main control panel as well as the telemetry unit for remote monitoring. When the blower is first started, the low air flow switch is inhibited from locking out the blower until timer TDR times out, normally set for 20 minutes. After the 20 minutes, if there is low air flow, the system will be shut down and will require manual restart.

The low flow switch is time dependent. Instantaneous or transient low flow conditions would not result in system shutdown. However, persistent low flow conditions of 20 minutes or longer will result in system shutdown.

3.5.1.2 Air/Water Separator Water Level Controls

The air/water separator and condensate tank contains several operable unit controls for various operational conditions. Two of the controls are primary system interlocks that prevent system operation if certain operational conditions occur. The two interlock controls are a high-high water level in the air/water separator (LSHH-03) and a high-high level in the condensed liquid storage tank (LSHH-05). See Drawing E-2. If either of these conditions occur, the system will automatically shut down if operating, and will not be able to be started until the condition is corrected.

Two additional level control switches will be installed on the air/water separator. These level switches turn the water transfer pump P-1 on and off as needed when the H-O-A switch is in the Auto position. See Drawing E-2. As water in the bottom of the air/water separator rises, level switch LSH-03 is lifted which activates pump P-1 which pumps the collected water into the condensed liquid storage tank. When the water level in the air/water separator reaches the lower level switch, LSL-03, pump P-1 stops operation. Switches LSHH-03, LSH-03, and LSL-03 are all connected digitally to the telemetry unit for status indication. When the water level in the air/water separator tank reaches the High/High level, either the condensate pump has failed, or the condensate liquid storage tank is full, the system will automatically be shut down and alarmed. Prior to system start up, the water levels in the air/water separator and the water storage tank should be visually checked using the sight gauges (LG-06 and LG-08).

As a protection for pump P-1, a motor protection circuit has been specified to prevent pump or motor damage during upset conditions.

3.5.1.3 Particulate Filter Controls

Two particulate filter units have been included in the operable unit design for the protection of the treatment system components. The first particulate filter is located in the vapor inlet line into the primary carbon bed. This filter removes any sediment and grit in the vapor stream that is not removed in the air/water separator. The second particulate filter is placed between the secondary carbon bed and the vacuum blower. This filter removes any fine carbon dust and grit that could damage the vacuum blower. See Drawings E-2 and E-3. In order to keep the system operating efficiently and to prevent excessive blower loading as a result of a filter clogging, differential pressure gauges have been included in the design for each of the filters. The differential pressure indicators will have a range of 0 to 50 inches of water differential pressure and are indicated on Drawings E-2 and E-3 as DPI-23 and DPI-22, respectively.

Each of the differential pressure indicators will be manually monitored in the field during routine system monitoring. When a differential pressure of 25 inches of water column or greater is observed, the filter will be serviced, either by cleaning or replacing the filter element.

3.5.1.4 Solvent Vapor Analyzer

The solvent vapor analyzers are installed prior to the dilution air inlet air/water separator and between the primary and secondary carbon bed, and provide a means for evaluating system contaminant recovery, treatment performance, as well as determining when the carbon beds will require service. The solvent vapor analyzer locations, indicated on Drawing E-2 as AE-08 and AE-11, will not be wired into the system interlocks and will not have the ability to automatically shut the treatment system down. Automatic shutdown of the system is not necessary when solvent vapors are detected between the primary and secondary carbons beds because the secondary carbon bed will have sufficient capacity to treat the solvent-laden air for several days to weeks without violating the air discharge regulations.

The instrument will consist of a ultraviolet light photoionization detector (PID) that is calibrated at the factory and in the field to TCE. An analog output from the PID will be transmitted to the telemetry for system remote monitoring. A chart recorder has not been included but can be added if required by Maricopa County. The solvent vapor analyzer will be operated in accordance with the Operable Unit Operation and Maintenance Manual (Appendix A) and will be maintained and serviced in accordance with the manufacturers' recommendations.

3.5.1.5 Blower Temperature Controls

To protect the operable unit vacuum blower, two primary temperature indicators have been installed to monitor the system. One temperature element monitors the blower inlet temperature (TE-17) and one temperature indicator monitors the discharge temperature of the vacuum blower (TI-21). Due to the nature and specified operational parameters of the vacuum blower, heat is generated during system operation. The inlet and discharge temperature elements will allow for the determination of high inlet temperatures and excessive discharge temperatures. Temperature element TE-17 has been installed

as an analog input to the telemetry system to continuously evaluate the carbon operational conditions and to determine carbon adsorption efficiency.

The temperature element TE-17 is not tied to the system interlock, and therefore will not shut the system down. Temperature shutdown is not considered necessary due to the other controls that will shut the system down prior to the development of excessive temperatures. These shutdowns include blower motor overload and low air flow rate. The operator also has the option of shutting the operable unit down locally or remotely by telemetry if the temperature readings are deemed excessive by the blower manufacturer. Temperatures in excess of 250°F would be considered excessive and would constitute shut down conditions. The temperature element will be connected to the telemetry via an analog signal for variable temperature readout.

3.5.1.6 Blower Motor Control

To provide overload protection to the operable unit vacuum blower motor, a motor protection circuit has been specified. The blower motor protection element, ISH-19, protects the motor in the case that an overload condition should exist. See Drawing E-3. The blower motor protection circuit is part of the main system interlock circuit which will shut the system down if an upset condition occurs during operation and will not allow the system to be re-started until the condition is corrected. System restart will only be able to be accomplished locally at the system control panel, and not remotely by telemetry.

3.5.2 Operable Unit Electrical Connections

The soil vapor extraction operable unit has been designed to treat solvent vapor extracted from the subsurface. Due to the potential for explosive conditions in or around the treatment area, the components of the operable unit have been designed and specified for National Electric Code (NEC) Class I, Division II operations. This NEC classification pertains to the operation of electrical equipment in explosive environments and requires enclosure of sparking or arcing devices

(hermetically sealed) or the use of non-sparking or arcing devices. The Class I, Division II area is defined as a 25 foot radius around the treatment unit.

All operable unit components with the exception of the electrical panels are specified as Class I, Division II. The electrical control panel, telemetry unit, and the operable unit power distribution module will be located outside the Class I, Division II area and, therefor, will not need to satisfy the requirements of this NEC classification. See Drawing M-1, Detail 1 for the treatment system layout. All connections between the main control panel and the operable unit components will be made through electrical conduit buried a minimum of 18 inches below grade. All electrical conduits will have the appropriate explosion-proof seal-offs in accordance with NEC Class I, Division II requirements.

Power that will be provided to the power distribution module (Drawing M-1, Detail 1 and Drawing E-4 and E-6) will be 480 Volt AC, 100 Amp, 3 phase service. This service will then be distributed to the individual operable unit components in the power distribution module. See Drawing M-1, Detail 1 and Drawings E-4 and E-6. It has been assumed that overhead power in this configuration is available in the immediate vicinity of the operable unit and will not require a separate pole line or underground utility.

A single temporary power pole will be installed adjacent to the operable unit outside the Class I, Division II area for power connection. The main system control panel, power distribution module, and telemetry unit will be located adjacent to the power pole. In addition to the electrical service terminating at the power pole, a telephone line will be extended to the power pole for connection to the telemetry unit.

3.6 OPERABLE UNIT TREATMENT AREA AND SECURITY

The operable unit treatment area has been designed to provide a secure and structurally sound area for the treatment system to be located. Drawing M-1, Detail 1 illustrates the operable unit treatment area.

A total of two primary skids, the air/water separator skid and the blower skid are required to be mounted and anchored to a concrete pad for structural and vibrational concerns. The concrete pad will be approximately 10 feet wide by 18 feet long. Pad thickness will be no less than 6 inches with minimum No. 4 rebar. The concrete will be 3000 psi commercial mix with no additives and will be poured in forms on a graded and compacted base. Drawing M-4, Detail 16 illustrates the concrete a typical pad construction as well as ground preparation considerations. Figure 3-1 was used to determine the water drainage characteristics for a 25 year, 24 hour rain storm event. Due to the small treatment area size, no drainage control was deemed necessary. The operable unit skids will be mounted on the concrete pad as illustrated in Drawing M-1, Detail 1. The skids will be anchored to the pads through the use of anchor bolts formed a minimum of three inches in the concrete pad. Rubber vibration dampening pads will be placed between the blower skid and the concrete pad to minimize pad vibrations and noise.

The carbon vessel skids will be located off the treatment pad closest to the treatment area gates to facilitate monitoring and carbon bed replacement and/or regeneration. The carbon beds will be piped above ground using vacuum-rated flexible tubing to the air/water separator and vacuum blower as indicated in Drawing M-1, Detail 1. The flexible tubing will facilitate easy connection of the beds during servicing. Sufficient room will be left around the operable unit components for operators and service technicians to maintain the operable unit equipment. A single junction box will be installed on the vacuum blower side of the pad for all operable unit electrical and control wiring to be pulled. The junction box will be rated for Class I, Division II operation.

The electrical control panel, power distribution module, and the telemetry unit will be placed on a separate concrete pad of similar construction outside the Class I, Division II area. See Drawing M-1, Detail 1. The dimensions of the electrical control pad are approximately 10 feet by 5 feet. A fence or enclosure will be constructed around the electrical control panels to prevent tampering and damage from the weather. Drawing E-6 illustrates the configuration of the electrical control panels.

For operable unit security, a chain link fence will be erected around the operable unit. The fence will be a minimum of eight feet high, will have barbed wire around the top of the fence, and will have

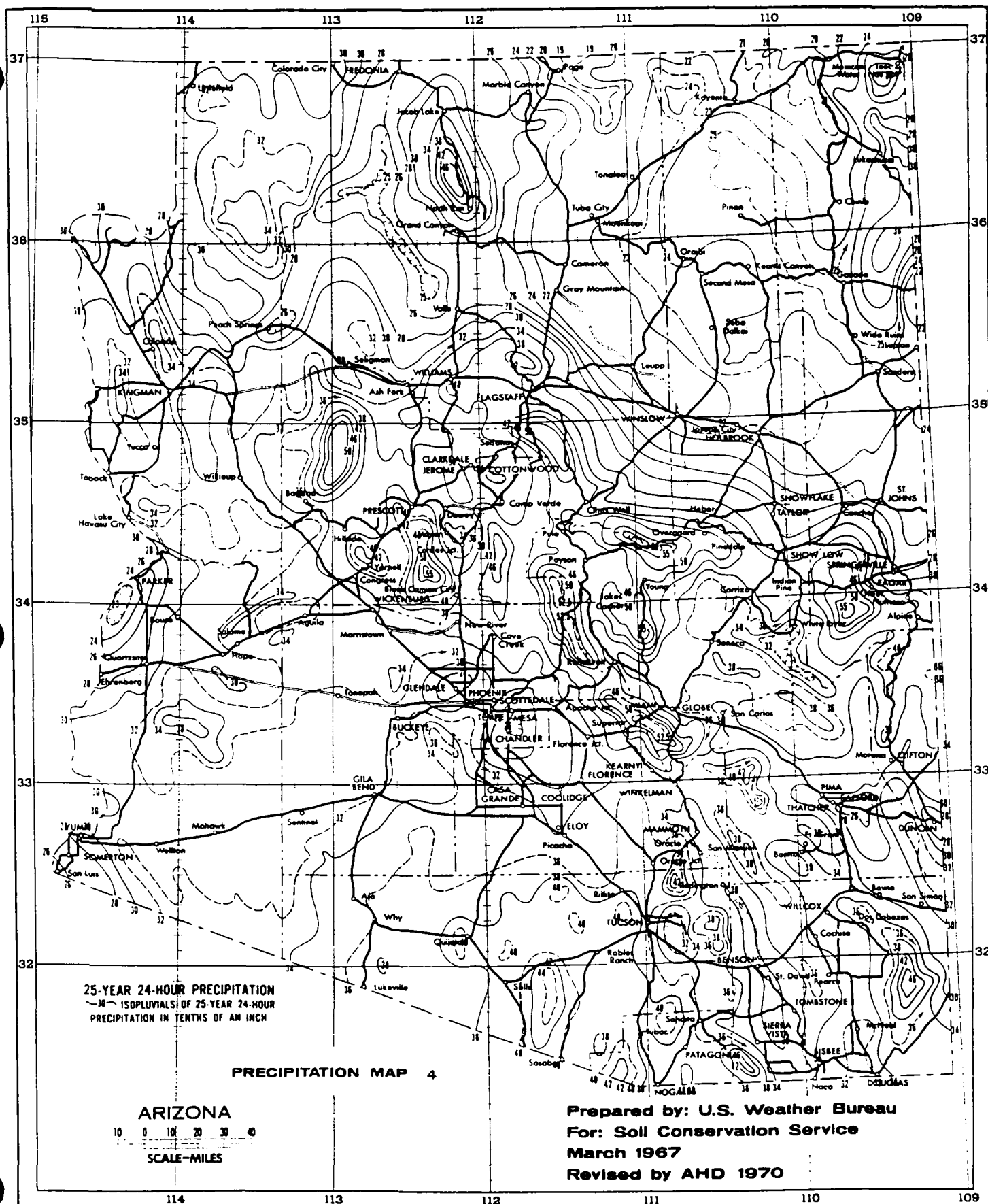


FIGURE 3-1

two-five foot wide swing gates for truck access. For additional security, concrete-filled steel posts will be installed at the corner of the treatment and electrical pad to prevent vehicle damage. Drawing M-1, Detail 1 illustrates the treatment area configuration including the fence and protection posts.

Signs will be posted on the security fence and on other potential safety hazards in the project area. Entry rules, which will require personnel entering the fenced area to check in with project management, will be posted near the entrance gate. Signs within the treatment area will identify potential electrical hazards and hot surfaces. Warnings of hazardous and combustible materials will be posted. Other warning signs, such as eye, foot, and hearing protection requirements will be posted as appropriate. OSHA training will be required for site entry.

SECTION FOUR

PHASE I HORIZONTAL INVESTIGATION

4.1 SAMPLING AND DATA OBJECTIVES

Based on the collective results of the refined VLEACH and Mixing Cell screening, M&E will conduct a phased field investigation to characterize the vertical and lateral extent of TCE contamination in soil vapor at nine polygons at the PGA site. The nine polygons were demonstrated to fail the initial screening test Method #1 as detailed in Section 2 of this report including the refined VLEACH and Mixing Cell screening. The nine polygons include 21A-26A, 113, 111, 13A, 96, 65, 38, 36, and 15A. From the nine polygons highlighted in this SVE Final Design Document, M&E will collect soil vapor samples at four predetermined locations in each of the polygons, and at five locations in polygon 21A, 26A (thirty-seven total locations) from vapor probes mechanically driven into the shallow subsurface. Two soil vapor samples will be collected at each location, both above and below the caliche layer (occurring approximately 10-15 feet below grade), for a total of 74 total samples plus QA/QC samples. All collected soil vapor samples will be immediately analyzed in the field using a gas chromatograph. Analytical data generated from these sample analyses will be contoured in the field using a kriging technique. Kriging is a geostatistical technique which is best described as a family of methods used for the purpose of optimal nonlinear spatial prediction. The kriging technique employs a form of weighted averaging in which the weights are chosen such that the error associated with predictors is less than that for any other linear sum. The weights depend upon the location of the points used in the prediction process and upon their covariation.

Golden Software, Inc. Surfer program (version 4) will be used for kriging the soil vapor survey data to generate contoured maps of Phase I soil vapor data in each of the four polygons. The generated contour map will be used to determine the location of the greatest soil vapor concentrations within each Phase I investigated polygon. Based on these data, pending U.S. EPA site representative concurrence, a proposed Phase II boring will be positioned at the location demonstrating the highest total VOC concentrations as TCE (TCE, PCE, 1,1-DCE, and 1,1,1-TCA) within each of the nine

polygons. The use of the Phase I lateral shallow soil vapor survey will be used solely to determine appropriate Phase II investigation locations and will not be used as a means of estimating VOC masses in the vadose zone.

Conducting the field investigation in phases will provide data for more accurate and representative VLEACH and Mixing Cell screening or as aid in the preparation of the design of the SVE operable unit remedy for additional polygons requiring SVE operable unit remedy. It will also provide for the development of a more complete and focused investigation of polygons failing the refined VLEACH and Mixing Cell screening (Class 2 polygons). Following the investigation of the nine (9) polygons, the results of the refined VLEACH and Mixing Cell screening will establish a revised prioritization of the screened polygons. Polygons that have been investigated as outlined in this SVE Final Design Document and fail the refined VLEACH and Mixing Cell screening (Class 2 polygons) will be prioritized for SVE remedy with the most contaminated polygons receiving the highest priority. Those polygons not investigated but screened with VLEACH and Mixing Cell using the refined physical data and the 1989 RI/FS contamination concentration and vertical distribution data and still fail VLEACH and Mixing Cell will be prioritized for Phase I/II investigation. Polygons passing the refined VLEACH and Mixing Cell screening (Class 1 polygons) that have been investigated as detailed in the SVE Design Memorandum will be dropped from further investigation or SVE remedy consideration.

The methodology for the field investigation scope of work is presented in the following sections.

4.2 SOIL VAPOR SAMPLING LOCATIONS/METHODOLOGY

In order to determine the area of highest VOC concentrations as TCE within the four prioritized polygons highlighted in this SVE Final Design Document. M&E proposes to conduct a phased investigation of the polygons. This phased investigation will consist of two primary phases. Phase I will evaluate the present shallow TCE soil vapor concentrations specifically across the nine polygons and Phase II will develop a vertical distribution of TCE soil vapor within the vadose zone. This survey is designed to assess the current levels of TCE in soil vapor for refined VLEACH and Mixing Cell screening as well as Soil Vapor Extraction system design purposes to supplement the 1989 RI/FS

soil vapor data. Specifically, M&E will conduct the Phase I soil vapor survey on polygons 21A-26A, 111, 113, 13A, 96, 65, 38, 36, and 15A to generate a contoured soil vapor concentration map of each investigated polygon which will indicate the area within each polygon that is expected to contain the greatest soil vapor concentrations at depth. This data will be used for the purpose of scientifically establishing the location of the proposed Phase II boring that will likely intersect vadose zone soils which exhibit the greatest VOC concentrations within each of the four polygons.

The soil vapor survey will be conducted in two phases, the first phase, Phase I (Section 4) will develop the lateral distribution of soil vapor over the polygons above and below the site caliche layer and will be limited to depths of 5-10 feet below grade and approximately 15-20 feet below grade. The second phase, Phase II (Section 5) will develop a vertical profile of soil vapor concentrations to the water table/capillary fringe through the installation of a soil boring and depth-discrete soil vapor monitoring well cluster for each of the nine polygons.

4.2.1 Phase I Horizontal Investigation Description

Phase I of this investigation will involve shallow soil vapor sampling at locations roughly coincident with the vapor probe survey conducted during the 1989 RI/FS investigation. Phase I is designed to isolate the location of the highest VOC concentrations (as TCE) in the shallow vadose zone both above and below the caliche layer for the purpose of locating the Phase II soil boring. Proposed sampling locations in addition to the historic 1989 RI/FS locations include three additional locations positioned in each of the four polygons so as to maximize areal coverage (Drawing P-1, Appendix K).

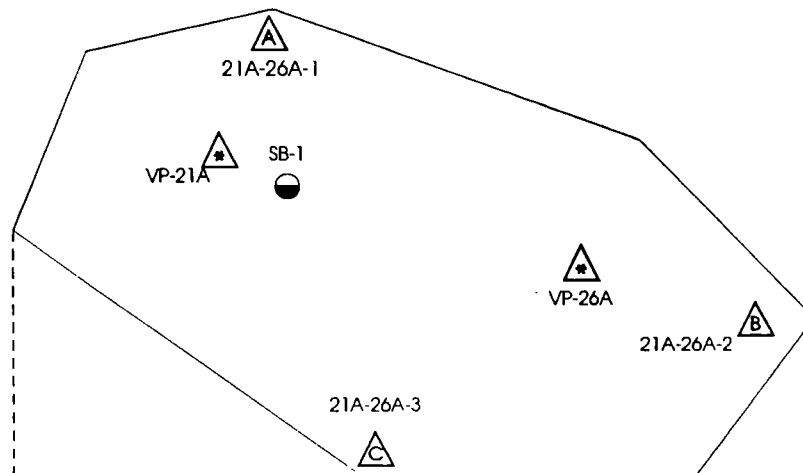
Prior to initiating sampling activities, M&E will have the nodes of the four polygons and proposed sampling locations marked by a state-registered surveyor. In this case, the number of stakes driven (at the nodes) will correspond to the number of sides characterizing each polygon. Delineation of polygon boundaries and sampling locations will permit the field crew to accurately determine the distance to polygon boundaries and to move proposed sampling locations relative to polygon boundaries if access problems exist due to structures or subsurface utilities.

Vapor probes will be located roughly coincident with the historic sampling locations because the historic sampling locations have been placed in what roughly corresponds to the center of each polygon. M&E proposes to incorporate sampling methodologies and analyses during the Phase I investigation as close as possible to those used in 1989 such that comparison of data will be as unbiased as possible.

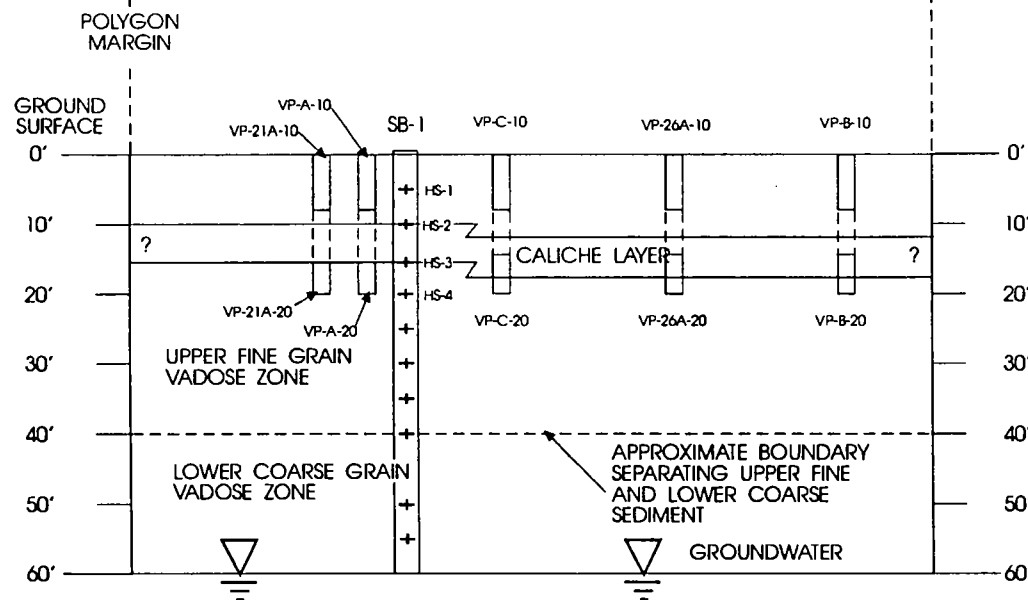
By increasing the shallow soil vapor database fourfold, greater sample validity and areal coverage within the four polygons will be obtained. These additional vapor probes will be located within each polygon using a combination random/systematic approach in positioning probes with the end objective of maximizing areal coverage within each investigated polygon.

Figure 4-1 illustrates an idealized strategy for additional vapor probe locations within a typical polygon. Shown in this diagram is combined polygon #21A-26A for illustration. Referring to Figure 4-1, it is shown that the two sampling locations denoted as 21A-26A-1 and 21A-26A-3 correspond to approximate 1989 soil vapor sampling locations. The three additional soil vapor sampling locations are positioned to provide maximum lateral coverage of the polygon area which results in sample locations toward the northeast and southwest margins of the polygon. Vapor probes will be positioned throughout the polygon to spatially determine the concentrations of TCE in soil vapor. Due to the existence of historical soil vapor data near the center of the polygons, M&E has positioned the additional soil vapor locations labelled VP-A through VP-C near the borders since interpretation can be drawn on current relative soil vapor concentrations in adjacent polygons through sampling at borders.

Three polygon soil vapor border conditions exist at the PGA site and each condition warrants a slightly different approach toward positioning of soil vapor probes. Where Class 2 polygons are bordered by non-polygon areas (where no detectable levels of halocarbons were found in soil vapor which includes Regions 1, 2, and 4), or along polygons which were determined to pass screening method #1 (Class 0 polygons), soil vapor sampling along such borders is not considered necessary. In these cases, vapor probes will be positioned to maximize areal coverage within the Class 2 polygons. However, where



MAP VIEW
NOT TO SCALE



X - SECTIONAL VIEW
NOT TO SCALE

LEGEND

- △ VP-21-A-10 1986/87 HISTORIC SOIL GAS LOCATION TO BE RESAMPLED
- △ VP-A DESIGN MEMORANDUM SOIL GAS SAMPLE LOCATION (PHASE I)
- VP-21A-10 1986/87 HISTORIC SOIL GAS LOCATION ABOVE CALICHE LAYER
- VP-21A-20 1986/87 HISTORIC SOIL GAS LOCATION BELOW CALICHE LAYER
- SB-1 PHASE 2 SOIL BORING TO WATER TABLE (POSITIONED OVER HIGHEST DETECTED TCE)
- + HS-4 SOIL SAMPLE VAPOR HEADSPACE (COLLECTED AT 5' INTERVALS FROM GRADE TO THE WATER TABLE)

PROPOSED SOIL VAPOR PROBE SURVEY STRATEGY FOR A TYPICAL POLYGON

GOODYEAR PGA

M&E Metcalf & Eddy

Drawn by:
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Number:
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Date:
10 November 1992

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Figure Number:
4-1

Class 2 polygons are bordered by Class 1 polygons, it is of primary importance to locate vapor probes along such borders to assess levels of halocarbon concentrations near these borders. Finally, where Class 2 polygons are bordered by one or more additional Class 2 polygons, borders are considered of secondary importance and the priority is to space vapor probes such that maximum coverage within each polygon is obtained. In these cases, additional vapor probes will be located approximately half the distance between the historic sampling locations and the Class 2 polygon common borders. By positioning probes half the distance to a common border, probe distribution can be maximized on both sides of a border. Drawing P-1, Appendix K, presents proposed Phase I/II Sampling Locations for the Class 2 polygons.

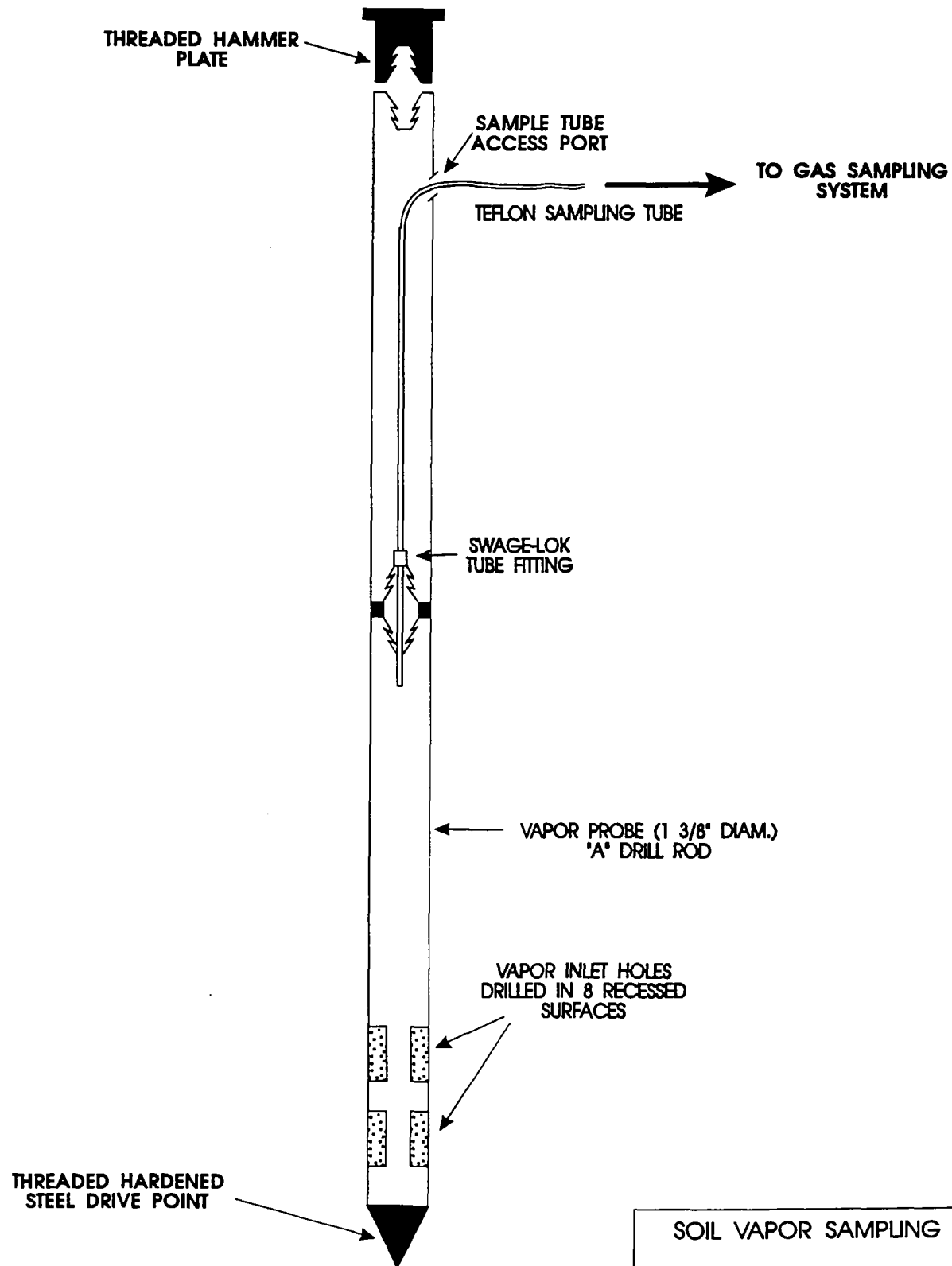
Table 4-1 presents a matrix which identifies each polygon border condition, establishes the relative investigative importance, and specifies the appropriate action to be taken.

TABLE 4-1				
SOIL VAPOR POLYGON BORDER CONDITIONS AND VAPOR PROBE DECISION MATRIX				
	Non-Polygon Soil Vapor Area	Class O Polygon	Class 1 Polygon	Class 2 Polygon
Class O Polygon	NA	NA	NA	B
Class 1 Polygon	NA	NA	NA	A
Class 2 Polygon	C	B	A	B
Protocol: A: Most important - Position probes near border(s) of Class 1 and 2 polygons. B: Moderate importance - Position probes so as to maximize areal coverage within Class 2 Polygon. (e.g. Not necessarily near borders). C: Least important - Placement protocol same as B.				

During the course of the Phase I horizontal soil vapor field investigation, real time data and/or field conditions may warrant a slightly modified location strategy of vapor probes within each Class 2 polygon. In these cases, M&E will rely on its expertise and input from U.S. EPA field oversight personnel in accordance with this SVE Final Design Document and the May, 1992 Design Memorandum and relocate vapor probes as this information becomes available. The goal of this initial investigation is to maximize the characterization of shallow, subsurface VOC concentrations as TCE in soil vapor within each Class 2 polygon using a limited number of additional soil vapor probes for the optimal location of the Phase II soil boring.

4.2.2 Soil Vapor Probe Emplacement (above caliche layer)

The shallow soil vapor probes will be driven using a truck-mounted hydraulic punch system with a percussion hammer assist. Vapor probe rods will be constructed of 5 foot lengths of threaded hardened steel alloy. The probe assembly is equipped with small diameter (1/16th-inch) vapor inlet holes drilled through eight recessed, machined surfaces; a machined, threaded drive point at the leading end; and a gas-tight swage-lok tubing fitting at the upper probe assembly. The recessed, vapor inlet hole configuration establishes a small annulus to remain between the hole wall and the probe, effectively preventing clogging. Figure 4-2 presents a diagram of the soil vapor probe. The rod assembly will be driven to 3 to 5 feet below ground surface at an identified sampling location within a polygon, the drive hammer raised, and a second rod segment will be threaded onto the probe assembly and driven until the approximate sampling depth of 10 feet is reached, which coincides with a depth just above the semi-continuous caliche layer at the site. Because the occurrence and depth of the upper, semi-continuous caliche, layer may vary at locations about the site, the actual depth of probe emplacement may vary based on field conditions as Phase I proceeds. The sampling tubing attached to the upper probe will be of sufficient length to be directed upwards through the rods, remaining accessible to sampling above ground surface. Inert modelling clay, if necessary, will be pressed into place around the hole created by the probe rods to prevent ambient air from circulating down the probe annular space and entering the sampling system, where feasible.



SOIL VAPOR SAMPLING PROBE



Metcalf & Eddy

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Figure Number:
4-2

4.2.3 Soil Vapor Probe Emplacement (below caliche layer)

Following the successful emplacement and sampling of the soil vapor probe above the caliche layer at an approximate depth of 10 feet below grade, a second sampling event will proceed at each location at a depth below the caliche layer (approximately 15-20 feet below grade). Initially, drilling will proceed in order to auger a pilot access hole to a depth of approximately 15 feet below grade, which is coincident with the lower extent of the caliche layer at the site. The intent of the pilot hole is to provide access for subsequent soil vapor probe emplacement below the caliche layer at each sampling location. Cuttings removed from the pilot access hole during drilling will be continuously logged by M&E to assess the depths and extent of caliche occurrence at each location and potentially refine sampling depths accordingly, if necessary. When the 15-foot depth is reached, the drilling augers will be removed and the decontaminated vapor probe assembly will be lowered into the bottom of the pilot hole. The probe assembly with threaded extension rods will be driven using a percussion hammer to a depth of at least 5 feet beyond the pilot hole depth to ensure both an effective seal between the probe and the native soils, and to breach the lower extent of the caliche layer and permit sampling of vapors in soils occurring below the caliche layer. When M&E has successfully emplaced the vapor probe in soils below the caliche layer at each sampling location, soil vapor sample extraction will proceed as described in Section 4.2.5.

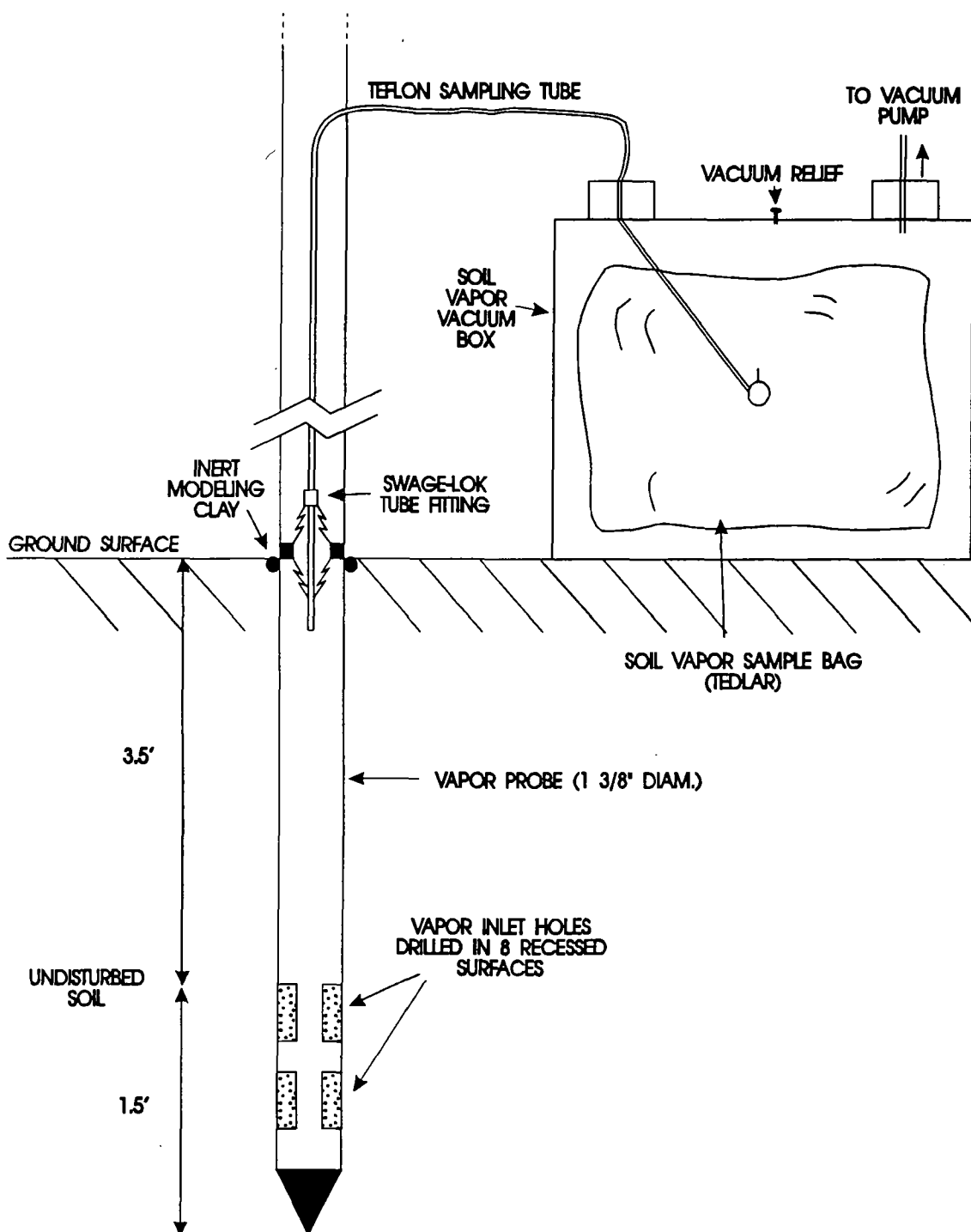
4.2.4 Soil Vapor Sample Extraction

A segment of new Teflon (PTFE) tubing attached to the vapor probe will be connected to the vacuum pump intake. Prior to sampling and purging, the system will be leak tested using a soap solution and all leaks will be sealed or replaced with new tubing. A low flow rate, high vacuum, diaphragm pump will be activated for a time period appropriate to purge approximately two open volumes of the sampling system. Two volumes will be purged unless a maximum VOC concentration is read as determined by continuous PID monitoring of purged vapor effluent, where at this point, this purging will cease. Vacuum from the sampling system will be monitored during purging and sampling to prevent overpumpage. The total mass of sample removed during purging will be recorded by a computer-controlled mass flow meter positioned between the pump and the tubing. Immediately

following purging, the tubing will be sealed off preserving the vacuum and allowing soil vapor to begin to migrate into the evacuated soil pores while preventing ambient air from entering the exposed tubing and dilute the soil vapor. When the vacuum instrument returns to its ambient reading (pressure prior to pumping), the pump will be reactivated and a soil vapor sample will be taken between the pump and the vapor probe by collecting the gas sample in a three-liter capacity Tedlar bag. Because of potential volatile losses from samples collected at the discharge end of the pump, M&E will use a soil vapor vacuum box. This technique utilizes the generation of a vacuum within a vacuum box, which reduces air pressure around the Tedlar bag through pumping. This results in a non-intrusive, non-contact flow of the soil vapor sample (which is connected to the vapor probe tubing) into the bag as pressures within the vacuum box begin to equalize. Figure 4-3 presents a schematic diagram of the soil vapor probe and vacuum box sampling assembly. Periodically, for QA/QC purposes, real time duplicate soil vapor samples will be collected from vapor probes by inserting a "tee" between two consecutive Tedlar bags. The vacuum instrument must read less than 90% of maximum vacuum to extract sufficient soil vapor during purging. If higher vacuums are observed, the native materials will be interpreted as too tight to yield representative soil vapor and the vapor probe will be moved to a new location.

4.2.5 Soil Vapor Analysis

All soil vapor samples collected from the four polygons during the Phase I sampling activities will be collected in three-liter capacity Tedlar bags and immediately forwarded to the mobile laboratory equipped with a gas chromatograph for analysis (see Appendix H for analytical protocol). Reported soil vapor concentrations will be in units of ppbV. The four VOC's reportedly detected in the subsurface at the PGA site (PCE, TCE, 1,1-DCE, and 1,1,1-TCA) will be summed to provide M&E with a total VOC concentration as TCE. The data generated from the Phase I investigation will be compiled and contoured for each polygon at depths both above and below the caliche layer. A marker will be set for the proposed Phase II soil boring at the location where the TCE concentrations are highest based on the contoured data. Placement of the Phase II boring will be agreed upon in the field with M&E and U.S. EPA field oversight personnel.



SOIL VAPOR SAMPLING PROBE
WITH VACUUM BOX



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Date:
September 1992

Checked by:
S. Zachary

Figure Number:
4-3

SECTION FIVE

PHASE II - VERTICAL INVESTIGATION

Upon completion of the Phase I horizontal investigation work, lateral iso-concentration contour maps of contaminant vapor using statistical kriging methods will be completed for each of the four polygons. Based on these data, a consensus for the proposed Phase II boring location will be arrived at in the field between M&E and U.S. EPA field oversight personnel. Following this decision, the Phase II investigation will begin, which involves drilling a single soil boring located at the highest concentration contour within each of the nine listed polygons in Section 4. Phase II sampling addresses characterization of the vertical distribution of site soil contamination.

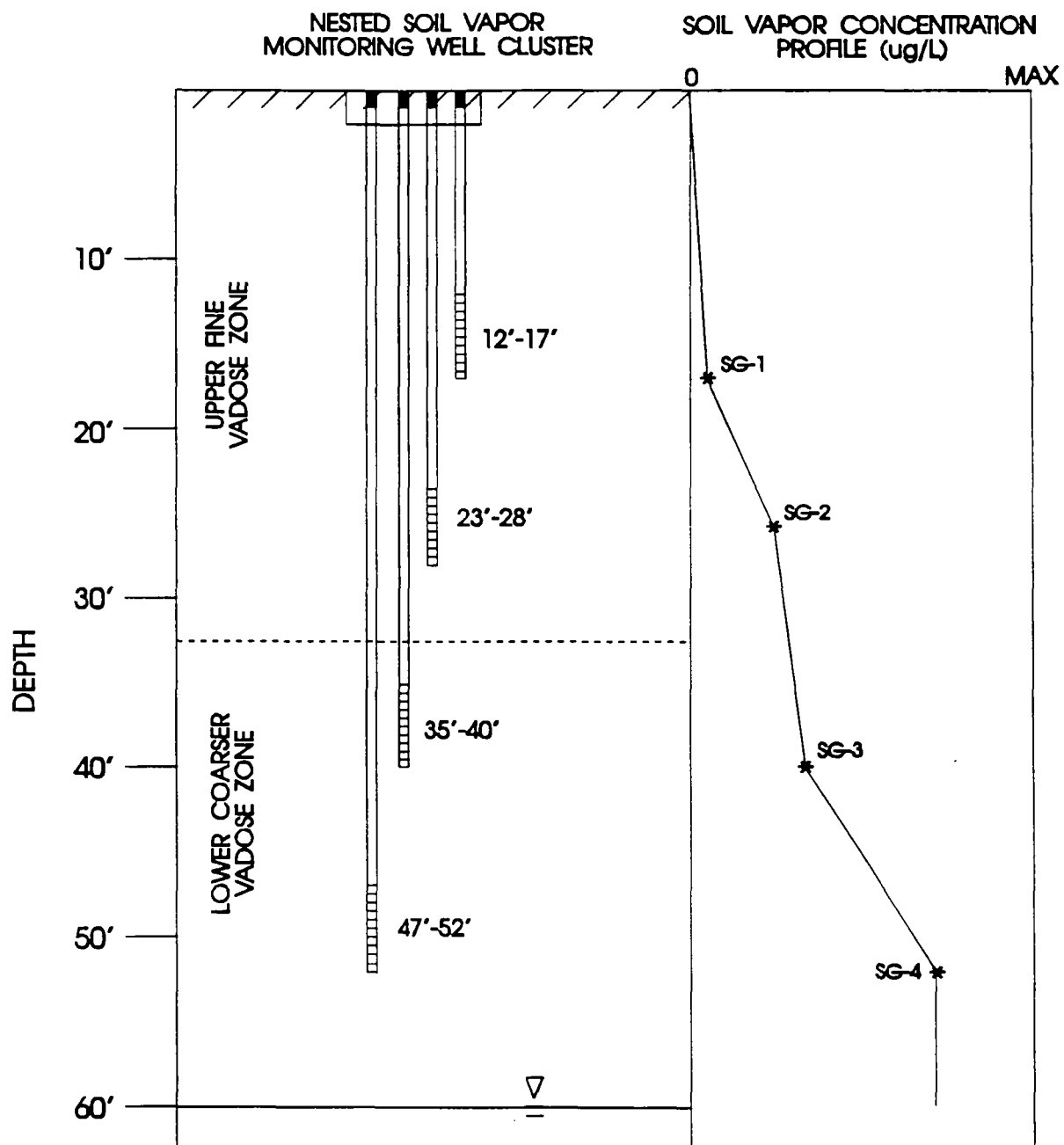
A single soil boring will be drilled from ground surface to just above the present elevation of the ground water table in each of the nine polygons using a hollow-stem auger drilling rig. The location of each soil boring will be within the area of detected and/or expected highest TCE soil vapor concentrations in each polygon as determined from results of the Phase I soil vapor probe survey. During drilling, soil core sampling at five (5) foot intervals is scheduled for the eight Phase II borings including polygons. Polygon 21A-26A is proposed to be continuously core sampled for lithologic confirmation of the site's vadose zone lithologic layers (see Section 5.1.1). Selected soil samples (one per boring) will be analyzed for VOC concentrations using full CLP laboratory protocol in order to establish baseline VOC concentrations for future evaluation of remedial progress and to facilitate site closure requirements. The on-site laboratory will perform soil headspace VOC analyses of soil samples extracted every five feet below grade in order to determine relative vertical soil concentrations, to select the highest TCE contaminated soil interval sample to be analyzed by CLP protocol, and to assist in selecting appropriate soil vapor monitoring well screening intervals (Section 5-3 and Appendix H).

Following the drilling and sampling of each Phase II boring, M&E proposes to convert each completed boring into a depth-specific vadose zone/soil vapor monitoring cluster well. The clustered

well configuration will consist of four individually completed vapor wells within each boring at specific depths within the vadose zone so as to maximize vertical soil vapor monitoring coverage (see Figure 2-3).

Following soil vapor monitoring well completion, M&E will sample each soil vapor monitoring well in each of the four polygons, and the collected samples will be submitted to a Certified laboratory for chemical analysis (see Appendix B for details). From the analytical results, M&E will develop a vertically distributed profile of soil vapor VOC (as TCE) contamination in each of the four polygons to establish input data for the refined VLEACH and Mixing Cell polygon screening. Figure 5-1 is an idealized drawing illustrating soil vapor sample locations, corresponding concentrations, and the derived vertical soil vapor distribution. Determination of TCE vertical distribution will be achieved by first converting all soil vapor concentrations in units of $\mu\text{g/L}$ to total soil concentrations in units of $\mu\text{g/Kg}$ (on a dry bulk basis) using equations presented in Section 2 and as described further in Appendix M. The total soil concentration ($\mu\text{g/Kg}$) data at specific depth intervals will be linearly extrapolated to the midpoints of depths corresponding to individual VLEACH soil vertical intervals (Section 2). M&E will then, upon U.S. EPA approval of the vertical soil concentration distribution profiling, extrapolate this data from the four polygons to all the Class 1/Class 2 polygons directly contiguous to the polygons investigated during the Phase II investigation. This revised vertical soil concentration distribution data for the contiguous polygons, with the remaining non-contiguous polygons screened using the original total soil concentration data and vertical soil intervals as presented in the Appendix S 1989 RI/FS, will be input into VLEACH and Mixing Cell. The programs will be run at one year increments over the thirty year modeling timespan.

Based on the results of this revised polygon screening, a determination will be made as to whether the polygon in question requires further investigation and SVE remediation as the operable unit remedy (eg. whether Subunit A ground water as determined from VLEACH and Mixing Cell result in TCE concentrations in excess of $5 \mu\text{g/L}$ over a thirty year timeframe). The decision for investigation or remediation of polygons failing the revised VLEACH and Mixing Cell screening will be based on investigation data.



* SG-1 = DEPTH-SPECIFIC SOIL GAS SAMPLE CONCENTRATION

IDEALIZED SCHEMATIC OF SOIL
GAS CONTAMINANT VERTICAL
DISTRIBUTION IN VADOSE ZONE



Metcalf & Eddy

Drawn by:
J. Weldmann

Job
Number:
006791

Date:
September 1992

Checked by:
S. Zachary

Figure Number:
5-1

Class 2 polygons which have been directly investigated using the methods described in the May, 1992 SVE Design Memorandum and continue to fail VLEACH and Mixing Cell screening will be prioritized for SVE remedy. Those polygons failing the revised VLEACH and Mixing Cell screening that have not been investigated as outlined in the SVE Design Memorandum will be prioritized for investigation and additional VLEACH and Mixing Cell screening. Polygons passing the revised VLEACH screening will not be considered for further investigation or SVE remedy.

5.1 METHODOLOGY

Borings will be advanced using the hollow stem auger drilling method with a truck mounted drill rig. The hollow stem auger drill has the proven capability to drill through caliche and indurated sediments containing boulders. Additionally, continuous core sampling capabilities will be required of the selected drill rig. The Central Mining Equipment (CME) Model 75 HD rig or equivalent is the selected candidate of choice, having high torque capabilities. The auger diameter will be 8.25 inches O.D. which is sufficient to permit 3 inch diameter core sampling, 4 inch diameter well installation where appropriate, and the capacity to drill through moderate cobble zones.

The subcontracted drilling crew shall be 40 hour-OSHA trained and certified, and have past experience drilling in the area of the PGA site. The drillers will be responsible for providing on-site grout mixing and auger decontamination capabilities. All drilling supplies will be transported to the site by the rig and support vehicle prior to drilling activities. Section 7 of this Report contains the policy for Residuals Management of drilling cuttings and health and safety equipment.

5.1.1 Phase II Soil Sampling

Sampling during drilling will include continuous core soil samples collected from ground surface to just above the ground water table using 2.5 foot long sleeves at polygon 21A-26A. Collected 2.5 foot length core sleeves will be lithologically logged using the Unified Soil Classification System,

appropriately labelled, and photographed by the site geologist. Continuous core sampling in this polygon is designed to provide M&E with a complete lithologic profile of the entire vadose zone.

In the remaining eight (8) polygons, soil samples will be collected and logged from the soil borings at five foot intervals using a hammer driven, 24-inch length, 2-inch diameter, modified split-spoon sampler lined with 2-inch diameter by 3-inch length stainless steel liners (see Figure 4-1 for a representation of Phase II soil sampling intervals). Liners from each 5-foot soil sampling interval collected will be field screened and logged by a site geologist, and replicates will be prepared for headspace analysis by the on-site mobile laboratory (see Section 5-2). Soil headspace analytical results were used solely to adjust vertical positioning of soil vapor monitoring well screen locations. Vertical profiling of soil headspace concentrations with depth is important as it relates to the PGA site since contaminants would be expected to migrate from the two distinct sources in the vadose zone:

1. surface soils resulting from surface spills and releases
2. the capillary fringe overlaying the ground water which would result from off-gassing of volatiles in contaminated ground water.

By vertically profiling soil concentrations, M&E can qualitatively identify and isolate sources of contamination and target these areas for VLEACH and Mixing Cell modelling and subsequent soil vapor monitoring and SVE remedy if required.

Replicate liners for potential off-site chemical testing will be immediately labelled and sealed by placing Teflon liners over the exposed ends secured in place by tight fitting plastic end caps, and placed in chilled coolers. Table 5-1 summarizes the total number and type of sampling proposed for the Phase I and Phase II efforts of this investigation.

TABLE 5-1

**PROPOSED SOIL AND SOIL VAPOR SAMPLING SCHEDULE FOR PHASE I
AND PHASE II INVESTIGATION ACTIVITIES - CLASS 2 POLYGONS**

Parameter Phase #	Analytical Method	Shallow Soil Vapor	Soil Vapor (Depth Specific)	Soil Core*	Trip Blanks	Equipment Blanks	Duplicates
IND VOC's Phase I	On-site GC	74	NA	NA	NA	Daily (20)**	10% (7)
IND VOC's Phase II	Soil Headspace On-site GC U.S. EPA 3810	NA	NA	108	NA	Daily (30)**	10% (11)
TCL VOC's Phase II	U.S. EPA TO-14	NA	36	NA	9	10% (2)	10% (4)

* Denotes continuous core and split-spoon soil samples.

** Number of equipment blanks will correspond to 2 times the number of days (twice daily) that equipment is used in field.

TCL Target Compound List

On-site Analysis conducted by on-site mobile laboratory

CLP Analysis conducted by CLP laboratory (off-site)

NA Not Applicable

IND Denotes site indicator compounds (TCE, PCE, 1,1-DCE, 1,1,1-TCA)

5.2 SOIL SAMPLE ANALYSES

5.2.1 Chemical Soil Sample Analysis

Soil headspace analyses will be performed in the field on soils sampled every five feet in each of the four Phase II borings. Soil ring or core samples will be initially field screened using hand held flame ionization detector instrument and the reading recorded for each interval on a field boring log. A subsample from each depth interval will then be quickly transferred into a laboratory septum lined, 8-ounce capacity, pre-cleaned soil jar using a decontaminated stainless steel spatula to avoid volatile losses from the sample to the atmosphere. The samples will be forwarded to the on-site laboratory where a chemist will analyze the head space constituency and concentration of the VOC's present in the samples. Gaseous standards of known concentrations of the TCE, PCE, 1,1-DCE, and 1,1,1-TCA will be injected into the GC at regular intervals in order to track and maintain instrument calibration over time. Full QA/QC protocol for the field laboratory soil headspace screening is presented in Appendix H. Soil headspace analytical results will not be used in the development of the vertical contaminant distribution for VLEACH and Mixing Cell screening but will provide M&E with the means to both evaluate the vertical distribution and magnitude of VOC contamination in the vadose zone, and to select appropriate depth intervals to screen the clustered soil vapor monitoring wells.

5.3 SOIL VAPOR MONITORING WELL CLUSTER

5.3.1 Soil Vapor Monitoring Well Construction

Soil vapor monitoring well construction will immediately follow the drilling and sampling of the Phase II borings. Four monitoring wells, constructed in a nested fashion such that each of the four well is installed independently of one another are proposed for completion of each Phase II boring. Each well will be installed with one half (1/2)-inch diameter, Schedule 40 PVC casing, slotted with a five foot length screened interval at the base with blank casing extending upwards to just above ground surface. Figure 2-3 illustrates a typical soil vapor monitoring cluster well installation. The proposed construction using five foot screened lengths were selected to maximize the total screened depth of vadose zone soil vapor monitoring in each Phase II boring. Using this construction, a total of twenty feet of screen will be open to soil vapor sampling which is over 30% coverage of the entire vadose zone. The proposed screened intervals are as follows: 13-18 feet, 23-28 feet, 38-43 feet, and 53-58 feet below ground surface.

The rationale for proposing the four screened intervals is to characterize the upper fine vadose zone soils (13-18 feet), the approximate interface between the upper fine and lower coarse vadose zone soils (23-28 feet), and to characterize the lower coarse soils and the capillary fringe (38-43 feet, and 53-58 feet, respectively). The soil headspace analytical results will be used in conjunction with field observations gathered during Phase II boring activities in order to fine tune and potentially modify the screened interval schedule. It is noted herein that no screened interval, based on these additional data, will be moved more than five linear feet in either direction from its proposed location.

An idealized diagram of a typical vacuum monitoring/soil vapor monitoring well cluster is provided as Figure 2-3. The wells will be constructed in the order of greatest depth first, and proceeding upwards until the shallowest well installation is completed. A gravel pack will be installed around the screened interval, with a sand seal extending to approximately one half foot above and below each screened interval to prevent the bentonite seal from intruding through the gravel and sealing off the well screen. Above the sand seal, a one-foot thick pre-hydrated bentonite seal will be constructed to

seal each well from the influence of other wells constructed within the borehole. Above each bentonite seal, a 5 percent bentonite-cement mixture will be tremied into place to a depth corresponding to the next screening interval. At this stage, the construction process will be repeated until the shallowest well has been installed.

To complete each nested well installation, a 3-foot deep, 2.5 foot square pilot hole will be excavated into a one-foot thick layer of sand/gravel. A locking steel monument box will be positioned into the excavated hole and secured in place with a concrete envelope to complete the construction of each well. Each well will be labelled by a unique designation indicating its location, total depth, and screened depth interval. A well construction diagram will be completed for each nested construction.

5.3.2 Soil Vapor Monitoring Well Sampling

Following completion of the cluster wells in each of the nine polygons, M&E will purge and sample each well of soil vapor for submission to a Certified laboratory for chemical analysis of the targeted compounds listed in Table 5-2 using EPA Method TO-14. Full QA/QC protocol will be adhered to during purging, sampling, transport, and analysis of the collected soil vapor samples (Appendix H). M&E will allow a minimum of five working days to elapse following each well completion prior to sampling in order to allow the bentonite, grout, and cement to cure. Following this time period, M&E will purge and sample each well according to the protocol described in the following paragraphs and in Appendix H.

Each well will be initially purged of two (2) well volumes of vapor, or until a peak of VOC concentrations occurs, whichever comes first unless a maximum VOC concentration is reached as determined by PID-monitoring of pump effluent. At this point, a sample will be collected. This will be achieved by connecting a diaphragm pump to the well header, and allowing it to pump for a time period calculated by dividing product of two times each well volume capacity, by the pump rate determined during pumping. The result of this relationship yields the total pumping time required to

TABLE 5-2	
U.S. EPA METHOD 8240.	
TCL LISTING OF SCREENED ANALYTES	
DETECTION LIMIT IN SOIL VAPOR: 0.01 Mg/L	
Benzene Carbon tetrachloride Chlorobenzene Chloroform 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene Methylene chloride	Tetrachloroethene Toluene Trichloroethene (TCE) 1,1,1-Trichloroethane Vinyl chloride Total Xylenes
.Soil vapor will be analyzed under U.S. EPA Method TO-14 and specified for the above compounds as a subset of the U.S. EPA Method 8240 compound list.	

purge two well volumes for each individual well purged. The purge volume will be controlled by a computer-controlled mass flow controller. Pump rates will be determined using a rotameter, and pumping times will be measured using a stopwatch accurate to a least one-tenth of a second. The proposed two-well volume initial purge is considered to be sufficient to completely evacuate the well, and to initiate soil vapor flow into the well screen as is necessary to obtain "representative" native soil vapor in the immediate vicinity of the well screen without introducing problems of source depletion arising from overpurging. VOC concentrations will be monitored continuously during purging with a photoionization detector installed at the exhaust of the purge pump. Following purging, each well will be allowed to equilibrate to ambient pressure and remain static for a time period of at least ten minutes to allow time for VOC migration into the previously evacuated soil pores.

Following purging, each well will be prepared for soil vapor sampling. Initially, a stainless steel gas-tight fitting will be installed at each soil vapor wellhead. A new segment of one quarter (1/4)-inch diameter Teflon (PTFE) tubing will be attached to the wellhead fitting. A stainless steel passivated SUMMA canister equipped with a pre-cleaned mass flow controller calibrated to 200 ml/min will be

connected to the downstream segment of Teflon tubing (see Figure 2-5). Prior to sampling, the system will be leak checked using a soap solution and all noted leaks will be sealed or retrofitted with new components.

To initiate sample collection, a needle valve positioned between the SUMMA canister and the mass flow controller will be opened where the vacuum within the canister will provide the driving force necessary for sample collection. Sampling time will be set at 5 minutes which is sufficient time to result in a soil vapor sample volume of approximately 1.2 liters. Duplicate samples as indicated in Table 5-1 will be collected by using a second SUMMA canister and the identical sampling methodology.

All collected Phase II soil vapor monitoring well samples will be appropriately labelled and stored prior to transport to a Certified laboratory for chemical analysis of the targeted compounds listed in Table 5-2 using EPA Method TO-14. See Appendix H for QA/QC protocol.

Once all of the Phase II investigation data has been collected from the Class 2 polygons, the refined VLEACH and Mixing Cell screening will be run utilizing the new data. Investigated polygons which fail the refined VLEACH and Mixing Cell screening will be prioritized by TCE impact to Subunit A ground water and will be prioritized for SVE remedy. Polygons failing the refined VLEACH and Mixing Cell screening that have not been investigated as outlined in this document will be prioritized for Phase I and II investigation and further refined VLEACH and Mixing Cell screening. Investigation prioritization will also be based on impact to Subunit A ground water.

SECTION SIX

RESIDUALS MANAGEMENT

Waste products from the Phase I/II investigation will be drill cuttings from the soil borings, decontamination wastes, and miscellaneous wastes such as gloves, tyvex, etc. No contaminated soil residuals or health and safety equipment will be generated through the installation of the SVE operable unit.

The drill cuttings will be stored in lined roll-off bins or 55-gallon DOT drums. If roll-off bins are utilized, slotted PVC pipe will be placed in the lined roll-off bins prior to soil loading. The roll-off bins for the investigation of the first four polygons will be located in the Polygon to undergo SVE remedy adjacent to the area designated for the full-scale SVE treatment plant. Once the roll-off bin has been filled, the soil in the bins will be tested for VOC contamination using the field gas chromatograph and head space sampling method (see Appendix H). If detectable levels of contamination are found, the waste will be remediated through use of the full-scale mobile SVE treatment system. The treatment system will be the same unit for the remediation of the first Polygon which will contain vapor treatment to include granular activated carbon or a similar adsorption media. The soils in the roll-off bins will be treated with the SVE system until non-detectable concentrations of TCE are detected through the use of the field gas chromatogram and head space sampling method. When the levels of TCE are below the detection level of the field equipment, a grab soil sample will be collected from each roll-off bin and submitted to a CLP-approved laboratory for chemical analysis. If non-detectable levels of TCE are found, the soils will be classified as non-hazardous. Once the soil cuttings are classified as non-hazardous, they will be disposed of in an approved location on site to be agreed upon by Goodyear and U.S. EPA.

Any liquids collected from the decontamination of the drilling rigs will be temporarily stored in 55-gallon drums. All liquids will be treated through the Subunit A air stripper system. Any sediments collected as a result of decontamination will be mixed with the drill cuttings in the roll-off bins.

The disposal of spent activated carbon or adsorption media will be handled by the carbon or adsorption media contractor or vendor. Options available include transportation to an U.S. EPA-approved disposal facility or regeneration of the carbon by the manufacturer.

Miscellaneous wastes such as used health and safety equipment will be put in plastic bags and placed in 55-gallon drums for transport to an approved disposal facility or as common trash for disposal at a local landfill, depending on the level of hazards encountered during the work.

SECTION SEVEN

SCHEDULE

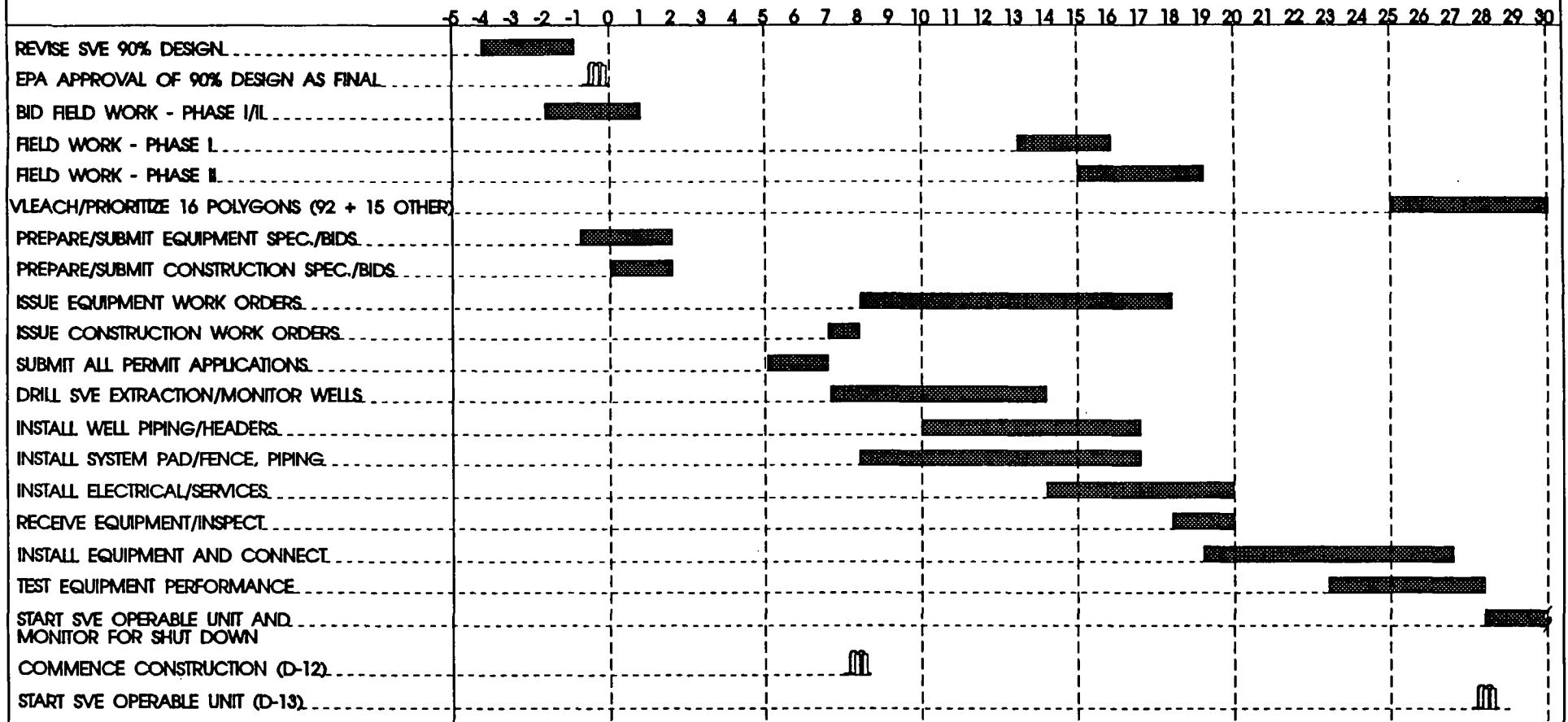
Upon acceptance of the Soil Vapor Extraction Operable Unit 90% Conceptual Design by U.S. EPA, Goodyear will proceed directly with carrying out the stated tasks.

All tasks will be carried out in accordance with the 1990 Consent Decree and its associated appendices as outlined in the SVE 90% Conceptual Design. The main tasks that will be carried out under the SVE Operable Unit 90% Conceptual Design include:

1. Prepared for Polygon 79 bid packages for equipment and construction services for the SVE Operable Unit.
2. Prepare bid packages for Phase I/II investigation subcontractors.
3. Conduct Phase I/II field activities.
4. VLEACH and Mixing Cell Model 9 polygons.
5. Install and test SVE Operable Unit in Polygon 79.
6. Prioritize site polygons for SVE remedy or Phase I/II investigations.

Each of these major schedule items is listed in Figure 7-1 and are broken into week-long segments. M&E will conduct all work in a timely manner in order to complete all of the listed tasks in Figure 7-1 and implement the SVE 90% Remedy within 210 days. The 210 day deadline is in accordance with schedule item D-12 of U.S. EPA Revised Consent Decree (letter from C. Copper, U.S. EPA to Ed Waltz of Goodyear Tire and Rubber Co. dated June 19, 1992). Within sixty (60) days after U.S. EPA approval, M&E will commence site construction activities which will include the installation of the soil vapor extraction and monitoring wells if SVE remedy is required (Schedule item D-13)

WEEKS FOLLOWING U.S. EPA APPROVAL OF SVE OPERABLE UNIT DESIGN



= DELIVERABLE MILESTONE

CONSTRUCTION WORK SCHEDULE

M&E

Metcalf & Eddy

Drawn by:
J. Weldmann

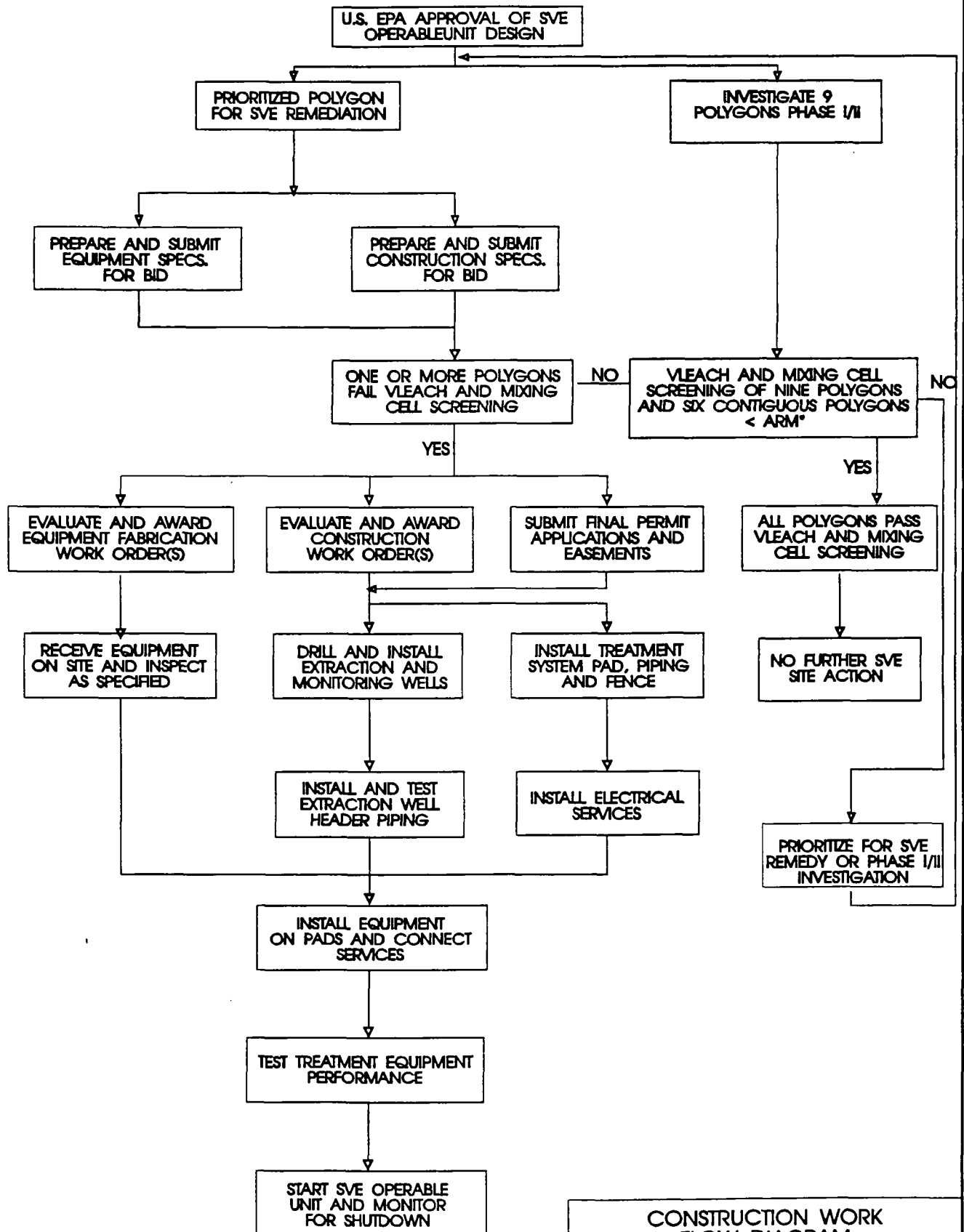
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Date:
November 25, 1992

Checked by:
S. Zachary

Figure Number:
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It should be noted that both the bidding/procurement process for the SVE Operable Unit components and construction contractors as well as the Phase I/II investigation of the nine polygons will be carried out together to ensure that the 210 day SVE Operable Unit is ready for start-up within the 210 day deadline. Figure 7-2 shows a flow chart of activities that will be conducted at the site in accordance with the project schedule.



* ARM = ALLOWABLE RESIDUAL MASS FOR NO SVE REMEDY

CONSTRUCTION WORK FLOW DIAGRAM

M&E Metcalf & Eddy

Drawn by:
J. Weldmann

Job
Number:
006791

Date:
November 24, 1992

Checked by:
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Figure Number:
7-2

SECTION EIGHT

REFERENCES

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8. Maskarenic, M.P., L.H. Johnson, and S.K. Holladay. 1988. Recommendations for Holding Times of Environmental Samples. Proceedings of the U.S. EPA Symposium on Waste Testing and Quality Assurance, Vol. II, July 11-15, The Weston Hotel, Washington, D.C., pp H-29 - H-45.
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APPENDIX A
DRAFT SVE OPERABLE UNIT OPERATION & MAINTENANCE MANUAL

The Draft Soil Vapor Extraction (SVE) Operable Unit Operation and Maintenance (O&M) Manual has been developed for an off-site regeneration carbon treatment system.

The SVE O&M Manual is in a draft form and contains several spaces within the document that are void of equipment-specific information. The equipment-specific information will be added to the SVE O&M Manual once provided by the individual equipment manufacturers.

The Draft SVE O&M Manual will be finalized start-up with the Final SVE OTM Manual to be submitted within 60 days after SVE system start-up (1990 Consent Decree, Section VII, Subsection D.14, p. 22). The SVE Operable Unit O&M Plan (Appendix A) and the SVE Extraction Well O&M Plan (Appendix B) will be combined into a single SVE O&M document prior to SVE system start-up.

The following sections describe the SVE, operable unit and its normal operation and maintenance components.

CONTENTS

Section

- 1.0 **SYSTEM COMPONENTS**
 - 1.1 Extraction Wells
 - 1.2 Piping System and Air Blending Station
 - 1.3 Vacuum Blower System
 - 1.4 Carbon Adsorption System
 - 1.5 Air/Water Separator
 - 1.5.1 Water Pump

- 2.0 **PROCESS DESCRIPTION/CONTROL**
 - 2.1 Process Description
 - 2.2 Instrumentation/Controls
 - 2.2.1 Blower System
 - 2.2.2 Carbon Adsorption System
 - 2.2.3 Air/Water Separator
 - 2.2.4 Photoionizer Detector
 - 2.2.5 Main Control Panel

- 3.0 **STARTUP PROCEDURES**
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 - 3.2 Preparation of Air/Water Separator and
 Condensate Tank
 - 3.3 Blower Startup
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 - 4.2 Sampling
 - 4.3 Components of VES On-Line
 - 4.4 Maintenance
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 - 4.4.2 Carbon Adsorption System
 - 4.4.3 Air/Water Separator

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- 5.0 PERSONNEL SAFETY
 - 5.1 Hearing Protection
 - 5.2 NEC Area Classification
 - 5.3 Guards
 - 5.4 Electrical
 - 5.5 Special Safety Precautions
 - 5.6 Extraction Wells

REFERENCE DOCUMENTS

- A (Blower)_____ Operation & Maintenance Manual
- B (Carbon)_____ Operation & Service Instructions
- C (Control Panel/Telemetry)___ O&M, Programming and Product Manual
- D (Air/Water Separator)___ Installation and Operating Instructions
- E Instrumentation O&M Manuals

1.0 SYSTEM COMPONENTS

1.1 EXTRACTION WELLS

Extraction wells are located throughout the polygon and are connected by an underground piping network. Refer to Drawing C-1 for exact locations. Each vapor extraction well will contain one soil vapor sample port for sample collection.

1.2 PIPING SYSTEM AND AIR BLENDING STATION

An interconnected piping system composed of PVC pipe ranging from 3 in. to 6 in. diameter transports the extracted solvent vapors from the well heads to the vapor treatment system. See Drawing C-1, Drawings M-1, M-2, M-3, and M-4.

An air blending station is located just prior to the vacuum blower. The station is composed of an 6 in. tee and butterfly valve open to the atmosphere. The butterfly valve should remain closed when the system is not in operation. See Drawing E-2.

1.3 VACUUM BLOWER SYSTEM

The vacuum blower system consists of an inlet air/water separator and filter, vacuum blower, discharge silencer, and control panel. See Drawing E-3.

The vacuum blower is Model _____, 2-lobe rotary positive type manufactured by _____.

The blower is driven by a 30 Hp, TEFC motor via a V-belt drive.

The blower is rated for 500 scfm at 15 in. Hg vacuum and 2 psi pressure.

1.4 CARBON ADSORPTION SYSTEM (CAS-1)

The Carbon Adsorption System is manufactured by _____ and consists of two GAC-filled adsorber vessels, and associated piping, ductwork and valves.

The adsorber vessels are 4 ft diameter, 7'3" long and of carbon steel construction. Each tank contains 2000 lb of _____ activated carbon supported by 18 gage stainless steel screens. The interior of the adsorber tanks are coated with an acid-resistant epoxy coating. The vessels are rated to 16 in Hg vacuum.

1.5 AIR/WATER SEPARATOR (AWS-1)

The air/water separator is a centrifugal force pressure drop unit with internal baffling and a discharge coalescing filter. The air/water separator contains a 150 gallon water reservoir for water storage. Liquid level controls are contained in the unit to control a water pump that evacuates the water reservoir as well as a high level shut down switch. The separator is made of carbon steel construction that contains a rust-inhibiting coating and is manufactured by _____

1.5.1 Water Pump (P-1)

The water pump is Model _____ manufactured by _____ driven by a 1.5 Hp, 1800 rpm explosion proof motor. The pump is rated for 20 gpm at 20 feet of water head.

2.0 PROCESS DESCRIPTION/CONTROL

2.1 PROCESS DESCRIPTION

During normal operation of the Vapor Extraction System, solvent vapor, consisting of chlorinated hydrocarbons and benzene, will be drawn from the soil within a given subsurface area by isolating the extraction wells located in the given area.

The hydrocarbon concentration of the SLA (Solvent Laden Air) is reduced, if necessary, if to below 25% of the LEL by mixing ambient air in the air blending station. It is anticipated that the solvent laden air from the wells will be less than 25% of the LEL (approx, 4,000 ppmV) under all operational conditions.

As the air/solvent mixture is drawn from the extraction wells, it will pass through an air/water separator on the inlet side of the blower system. Here, any liquid which has condensed out of the SLA will be separated from the SLA. The air/water separator operates under the extraction system vacuum. Thus, solvents dissolved in the water would, due to their relatively high vapor pressure, be removed from the water.

The water chamber in the air/water separator is equipped with mechanical level switches that control the water pump (P-1). When the water in the chamber reaches a preset level, the water pump (P-1) is energized. The water is pumped to a 250 gallon water tank. The water tank, located adjacent to the air/water separator, contains a high level system shutdown switch to prevent over-filling and/or spillage.

The air/solvent mixture will then pass through the Granular Activated Carbon (GAC) tanks. Inside the GAC tanks, Volatile Organic Compounds (VOC) including benzene, TCE, 1,1,1-TCA, 1,1-DCE, and PCE are adsorbed in a bed of high grade activated carbon. The carbon bed will continue to adsorb VOCs until it reaches its saturation at which time it must be regenerated or replaced. The length of time that a GAC tank remains in service will be determined by GAC breakthrough instrumentation. Initially,

carbon chargeouts might occur relatively frequently. As the remediation progresses, however, GAC units can be expected to provide longer service.

When carbon VOC breakthrough of the primary carbon bed occurs, the Carbon Adsorption System Vapor Analyzer will automatically detect the breakthrough and send the signal to the telemetry unit. The system has been designed with a two-tank series adsorption configuration to prevent releases to the atmosphere from solvent breakthrough. A photoionization detector which samples the "clean" air on the discharge header of the primary CAS will continuously monitor the "clean" air stream. If a solvent concentration above a pre-set level is detected, M&E can shut the system down via the telemetry unit or the site system shut-down switch. Following the breakthrough, M&E will schedule a carbon changeout. Subsequent changeouts will be set at less than one-half the time to breakthrough the primary CAS. This approach has a built-in safety factor to ensure that the secondary CAS does not experience breakthrough prior to primary CAS changeout.

Once the solvent vapors pass through the CAS, they are drawn to the blower system and exhausted out the blower discharge stack. Prior to stack discharge, the blower exhaust is routed through a discharge silencer to silence the blower exhaust.

2.2 INSTRUMENTATION/CONTROLS

All of the components of the VES (air/water separator, blower, CAS, filters, and pump) are designed to operate as an integrated package and therefor only one main control panel is used. Additional instrumentation and a telemetry unit have also been provided which tie the components together into an integrated system. This section will describe the instrumentation and control of each component as well as the system as a whole.

2.2.1 Blower System

The blower system is designed for continuous operation. Motor lubricating oil pressure, lubricating oil temperature and process air stream differential pressure are continuously monitored locally. The following conditions will result in a blower shut-down and an alarm signal to the main control panel:

- 1) Motor winding high temperature

Additionally, the following conditions will be locally indicated:

- 1) blower inlet pressure
- 2) blower discharge pressure
- 3) blower inlet temperature
- 4) blower discharge temperature
- 5) differential pressure of pitot tube (flowrate)
- 6) condensate level in inlet air/water separator (site glass)
- 7) differential pressure on particulate filters
- 8) water level in condensate storage tank

2.2.2 Carbon Adsorption System

A programmable logic controller is used to monitor functions of the carbon adsorption system. All valves, dampers, etc. are manually operated. Carbon bed temperature, vapor temperature, and process air pressure, are continuously monitored locally.

The following conditions will result in an alarm to the main control panel, but will not shut down the carbon system:

- 1) High carbon bed pressure (vacuum)
- 2) High solvent exhaust concentration
- 3) High water level in air/water separator
- 4) High water level in water storage tank

In addition, the programmable controller is configured to accept high alarm signals from a remote mounted Photoionization Detector. In the event of a high solvent concentration alarm, the programmable controller will notify by telephone M&E for system response.

The following conditions will be locally indicated:

- 1) Carbon bed temperature
- 2) Process air pressure
- 3) Process air temperature

2.2.3 Air/Water Separator

The air/water separator is equipped with mechanical level switches for controlling the water pump (P-1) and for sensing high liquid level in the separator.

If a high liquid level in the separator is sensed, the water pump will be activated, if a high-high level is sensed, an alarm signal will be sent to the main control panel to shut the system down.

When the water level in the air/water separator tank reaches the high/high level either the condensate pump has failed or the condensate liquid storage tank is full, the system will be shut down and alarmed. Check both tank levels before.

Vacuum within the separator will be locally indicated

The air exhaust line of the air/water separator contains a low air flow switch. In the event of system piping blockage, low air flow will result, automatically shutting the system down. See Drawing E-2.

When the blower is first started, the low air flow switch is inhibited from locking out the blower until timer TDR times out, normally set for 20 seconds. After the 20 seconds if there is low air flow, the system will be shut down and will require manual restart.

2.2.4 Photoionization Detector

A photoionization detector (PID) has been provided to continuously monitor solvent concentrations in the "clean" air stream between the carbon adsorption system primary and secondary beds. The PID is equipped with a circular chart recorder or equivalent device to provide a record of hydrocarbon concentration.

If the hydrocarbon concentration exceeds a preset high level, the PID will send an alarm signal to the system control panel. This signal will cause the system to notify M&E to service the unit via the telemetry unit. At this point, the system operator has the option of immediately responding to the unit or shutting the system down via telemetry and then responding to the unit.

2.2.5 Main Control Panel

If the main control panel receives an alarm signal from any component of the vapor extraction system, it will send a shutdown signal to the blower system and the carbon adsorption system. A pilot light on the main control panel will indicate the source of the alarm signal (blower system, carbon adsorption system, air/water separator, or PID).

System shutdown/start-up interlocks include:

- 1) low air flow in system from wells
- 2) High-high level in air/water separator
- 3) High-high level in condensed liquid storage tank

- 4) Blower overload
- 5) Telemetry lock-out

3.0 START-UP PROCEDURES

3.1 PREPARATION OF WELLS

Isolate the wells by closing the wellhead ball valves at the wells to be on-line. All valves on the 6-inch main header should remain open at all times.

Open fully air blending valve, at treatment unit. (V-).

3.2 PREPARATION OF AIR/WATER SEPARATOR AND CONDENSATE TANK

Prior to gas operation, remove the 4-in. inspection ports above the separation chamber of the air/water separator. Do not fill with water yet.

Before filling the air/water separator, the electrical panel must be ready and the water lines must be filled with water and the pump, P-1, must be tested for proper rotation and operation.

Open isolation valves V- and V- on the suction and discharge side of Pump P-1. Manually fill the air/water separator with water via hose. When the water level in the condensate tank reaches the pre-set level of the float switch, Pump P-1 should begin pumping water out of the condensate tank. Turn off the flow of water to the condensate drain line. Within several minutes, the water level in the condensate tank will reach the pre-set low-level limit and the level switch will close the switch Pump P-1 and the pump will stop.

Read pages _____ through _____ of the _____ O&M Manual and fill the air/water separator with water to the lower level float switch to maintain pump prime.

Replace the 4-in. inspection ports above the separation and water chambers of the air/water separator to prepare the system for operation.

Startup Procedure:

1. Check water level in air/water separator tank by looking at the level gauge, if high, then either manually drain tank by placing HAND-OFF-AUTO switch for the condensate transfer pump in HAND or automatically by placing switch in the AUTO position. When done, switch must be left in the AUTO position.
2. Check level in the condensate liquid storage tank by looking at the level gauge, if high, then drain properly.
3. Select sequencing of the carbon bed GAC and place valves in proper position as shown on Sheet E-4 valve table.
4. Check both intake and discharge temperatures of the blower.
5. Push ALARM RESET pushbutton to activate the electrical interlocks.
6. Start blower by pushing blower START pushbutton. System should start and be operating. If system shuts down, follow the interlock schedule below to find the cause of the system shutdown.

3.3 BLOWER STARTUP

Check that air blending valve, V-__ at the blower is fully open. Manually close both process air stream control valves on the inlets and outlets to the primary and secondary carbon tanks of the carbon adsorption system.

Read the "Safety Precautions" and "Startup Procedure" sections of the _____ O&M Manual. Follow the steps outlined in the Startup Procedures section until the blower is running with no load (air blending valve fully open).

3.4 BEGIN FLOW OF SLA

With the blower running, slowly increase the load on the blower and begin the flow of hydrocarbons from the wellheads by partially closing the air blending valve. Monitor the PID concentrations of the SLA as the air blending valve is slowly closed.

MAINTAIN THE SOLVENT CONCENTRATION IN THE SLA BELOW 25% OF THE LEL. Follow the procedures outlined in the Startup Procedures section of the

_____ O&M Manual while increasing the load on the blower.

Continue to run blower at full load (below 25% of LEL) for 24 hours. Check for proper operation of blower system components including high pressure shutoff, belt tension, filter elements, and lubricating fluids as described in the

_____ O&M Manual. After the blower has demonstrated satisfactory operation at full load for 24 hours, shut down blower and prepare carbon adsorption system for startup.

3.5 CARBON ADSORPTION SYSTEM STARTUP

Read and follow the procedures outlined in the System Operation section of the _____ O&M Manual until directed to "start the flow of SLA." Close the carbon system bypass valve, V-__, and restart the blower system. Follow the

remaining startup procedures outlined in the System Operation section of the _____ O&M Manual. During carbon system start-up, the PID monitor will be configured to sample the influent vapor prior to the primary GAC unit. These data will be used to estimate breakthrough times for the GAC bed.

All components of the VES are now operational. Continue to observe the overall operation of the system for several days.

4.0 OPERATION AND MAINTENANCE

Normal operation of the VES is continuous and fully automatic. However, manual process air stream sampling and manual adjusting of the air blending valve is required.

4.1 AIR BLENDING

Upon initial startup of the VES, the air blending valve should be throttled so that the solvent concentration of the SLA does not exceed 25% of the LEL. It is anticipated that solvent concentration will decrease with time for a given set of extraction wells on-line. Therefore, solvent concentrations in the SLA must be monitored on a daily basis (or as necessary) and the air blending valve throttled accordingly to maintain a solvent concentration in the SLA below 25% of the LEL.

4.2 SAMPLING

Refer to requirements of the air permit for sampling procedures and schedule.

4.3 COMPONENTS OF VES ON-LINE

Based on the results of laboratory gas chromatograph sampling, it will be necessary for the operators to determine which components of the VES should remain on-line. It is

anticipated that when new extraction wells are brought on-line, a high concentration of solvent vapors will exist in the SLA.

4.4 MAINTENANCE

4.4.1 Blower

Refer to page __, Section __ of the _____ operations manual for a description of preventative maintenance procedures and troubleshooting checklist.

4.4.2 Carbon Adsorption System

The Carbon Adsorption system has been designed for continuous operation and has very few moving parts. However, maintaining the system in proper operating condition with periodic scheduled maintenance is of utmost importance to the safe and efficient operation of the system. Estimation of the carbon life will be made based upon predicted carbon loading efficiency, and SLA flow rates and concentrations. This calculation is verified in the field with the continuous PID monitor located between the primary and secondary GAC beds.

Refer to the _____ Operation and Service Instructions Manual pages ____ - ____ for maintenance instructions.

The activated carbon will have a finite period of effective use. However, this lifetime is dependent of field conditions and cannot accurately be predicted.

_____ and _____ (activated carbon supplier) should be consulted in determining when the carbon should be replaced.

4.4.3 Air/Water Separator

Refer to the _____ Installation and Operating Instructions for a description of maintenance procedures.

5.0 PERSONNEL SAFETY

Each component of the vapor extraction system has been designed with safety features for the protection of operating personnel. Still, certain precautions must be taken by operating personnel and a thorough knowledge of potential dangers is required. This section outlines these potential dangers and precautionary procedures.

5.1 HEARING PROTECTION

The extraction blower will generate approximately 75 dB noise at 3 feet distance while in operation with the doors open. Since exposure to noise of this dB level can be harmful to humans, hearing protection is required for all personnel within a 25 ft radius of the extraction blower. Actual noise measurements will be taken during startup to verify the above information.

5.2 NATIONAL ELECTRIC CODE (NEC) AREA CLASSIFICATION

During operation of the VES, the hydrocarbon-laden airstream is blended with ambient air in order to reduce the hydrocarbon content to no more than 25% of the lower explosion limit. Therefore, the majority of the area of the VES is not classified as hazardous.

The carbon vessels are an area in which flammable gasses are stored and handled. As a result, the area defined by a 20 ft limit around the carbon units has been designated a Class 1, Division 2 area as defined by the N.E.C. Equipment within this area must be

rated for operation within a Class 1, Division 2 area and all other precautions appropriate to working within such an area must be taken by operating personnel.

5.3 GUARDS

All mechanical equipment with motion that may be hazardous to operating personnel must be guarded. This includes all couplings, belts, gears, sprockets, etc. Guarding shall be in compliance with OSHA standards.

5.4 ELECTRICAL

The installation of all electrical components, wiring, etc. must be in accordance with the N.E.C. and applicable state, county, and local building codes.

5.5 SPECIAL SAFETY PRECAUTIONS

The equipment manuals for the extraction blower system, the Carbon adsorption system, and the air/water separator contain safety precautions, safety features and warnings unique to each component. The equipment manuals must be read thoroughly and fully understood by operating personnel prior to system startup.

5.6 EXTRACTION WELLS

Special precaution should be taken whenever working on extraction wells which are located throughout the subarea, including traffic areas. Refer to Appendix B for well operation data and guidelines.

APPENDIX B
DRAFT SOIL VAPOR EXTRACTION (SVE) WELL OPERATION
AND MAINTENANCE PLAN

INTRODUCTION

This SVE extraction monitoring well O&M plan has been designed to provide the basis of sub-area operation, rebound monitoring, and closure activities. Due to the lack of polygon or sub-area specific data, the O&M plan is in draft form, is general, and addresses only the basis for and protocols of operation and monitoring.

During SVE operable unit start-up, Goodyear will develop the polygon or sub-area specific parameters needed for operation, monitoring, and closure. In addition to the parameters that will be established, a monitoring schedule will be developed to guide or prompt sub-area operation, rebound monitoring, and/or closure.

The sub-area specific parameters as well as the monitoring schedule and matrix will be submitted to U.S. EPA as an addendum to the SVE Final Design document no later than 60 days following start-up of the SVE system. (1990 Consent Decree, Section VII, Subsection D-14, p. 22).

The submittal of this addendum O&M document to U.S. EPA will be under one cover entitled Phoenix-Goodyear Airport Soil Vapor Extraction Operable Unit Operation and Maintenance Manual-Polygon 79.

This O&M manual will contain both the SVE extraction well, monitoring well, and treatment system information, currently separated in Appendix A and B of this document for review and comment purposes.

The following sections of this appendix present the Well Operation and Maintenance Plan for the first sub-area, Polygon 79.

B.1 START-UP OPERATIONS AND MAINTENANCE (O&M) PLAN

This section describes the methodologies that M&E will employ during start-up operations for the first sub-area extraction well located in Polygon 79 (see Drawing C-1, Appendix K). As defined in

Section 5 of the May, 1992 SVE Design Memorandum, the first extraction well will be located and will operate in the most highly contaminated sub-area of Polygon 79 based on the results of the Phase I/Phase II field investigation. The exact location of the sub-area extraction wells will be given allowance for the ability to install extraction wells within areas that may contain buildings or other impeding structures. All of the SVE extraction wells required to treat the entire polygon will be installed and initially operated together.

Historic work conducted at the PGA site has generated data regarding subsurface SVE Operable Unit conditions (Remedial Investigation Report, U.S. EPA, and Appendices of the 1989 RI/FS). However, because subsurface conditions are variable across the site and have likely changed somewhat since these historic studies, an initial soil vapor baseline sampling/analytical event will be completed. At the onset of SVE start-up for Polygon 79, soil vapor samples will be collected using SUMMA canisters from each monitoring well/piezometer (20 total + QA/QC samples) using the methodology discussed in Section 2.1.3.6 of the SVE Final Design Document, November, 1992. For baseline monitoring well sampling locations in Polygon 79, see Drawing C-1. All samples will be submitted to a certified laboratory for analysis using EPA Method TO-14. The results of this baseline sampling will establish current soil vapor concentrations at various locations throughout Polygon 79, establish the current vertical distribution of VOC contamination in each sub-area, and serve as a starting point with which to base SVE remedial progress on. In addition to baseline soil vapor sampling, sub-area specific subsurface parameters existing in the field will be developed during start-up to optimize SVE system operation and maximize the system efficiency.

During start-up, the following data and/or parameter measurements will be measured/determined at Polygon 79.

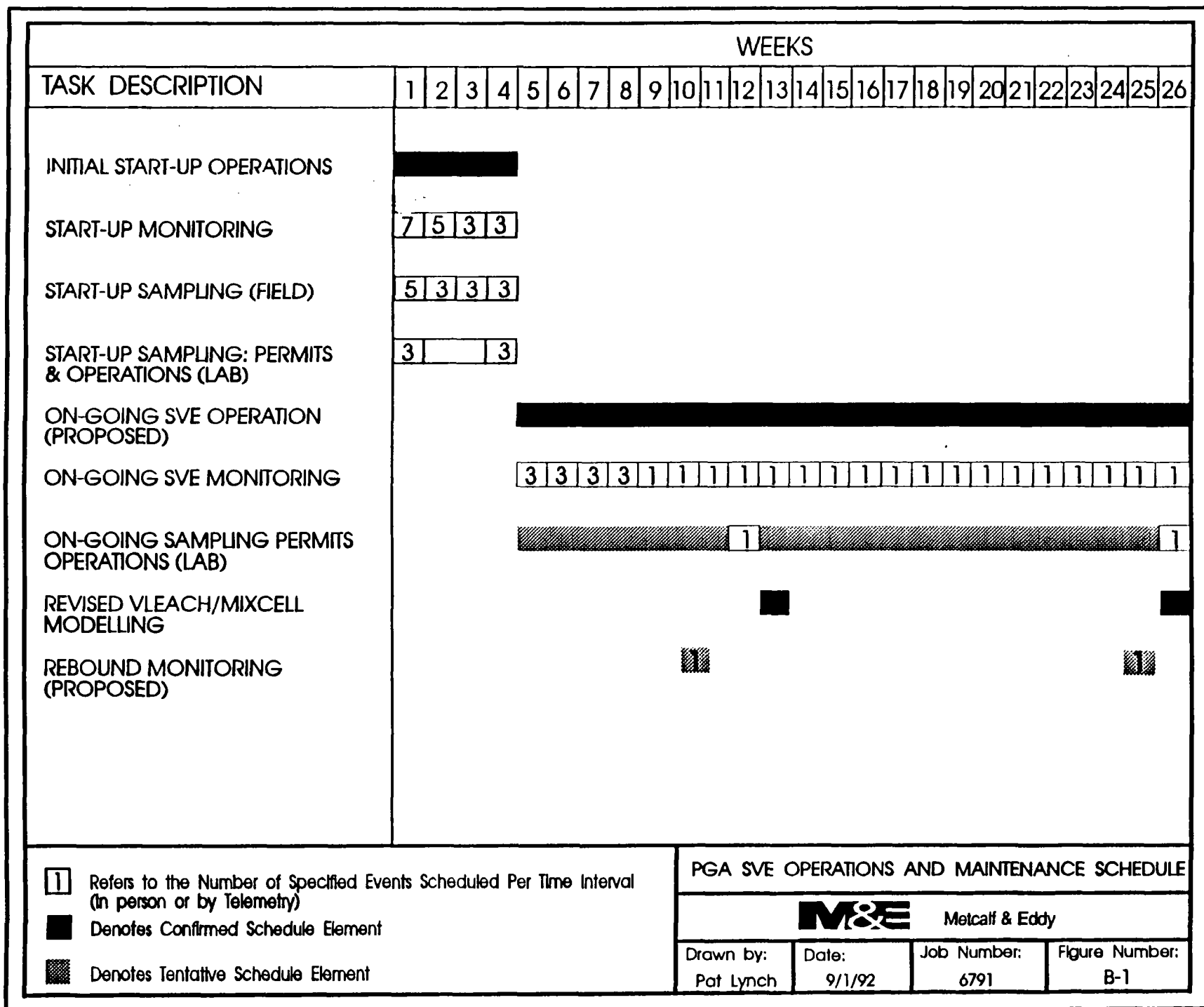
1. Extraction/monitoring wellhead temperature, vacuum, and flow rate
2. Radius of soil vacuum influence
3. Air permeability calculations for soils occurring within the radius of influence
4. Radial soil vapor velocity
5. Soil vapor flow field determination
6. SVE monitoring and extraction well soil vapor sampling/analysis

7. Soil vapor contaminant composition and maximum concentrations
8. Critical flow/vacuum rate determination
9. Extraction well efficiency
10. Sub-area remediation duration modeling
11. Subsurface VOC soil vapor concentrations and vertical profiles

The first extraction well will be operated during start-up for a period of time under both constant and variable flow rates and vacuums to permit measurement/determination of the above listed ten (10) elements. It should be noted that the determination of the listed parameters is not to be used for "pilot test" purposes, but rather, to determine and operate the SVE system at optimal parameters for time and cost effective remediation purposes. A schedule indicating proposed monitoring/measurement/sampling frequencies during start-up operations is provided as Figure B-1. This schedule may be modified accordingly as data becomes available following start-up of the first operational sub-area. The above listed parameters will be measured as required in the 1990 Consent Decree, Section VII, Subsection C-6 and will provide well operation information that will maximize operational efficiency and reduce sub-area clean up times. Measurement and/or calculations of the ten (10) elements will be carried out as follows (see Appendix H, QAPP). Once the parameters have been developed for the first well, or sub-area, the other site wells will be brought on line for SVE operation.

B.1.1 Extraction/Monitoring Well Temperature, Vacuum, and Flow Rate

At selected periods throughout on-going SVE operations at the first extraction well (sub-area 79), the temperature, vacuum differential, and soil vapor flow rate parameters will be directly measured from the SVE extraction well and SVE monitoring well(s) (see proposed schedule: Figure B-1). Temperature readings will be measured at wellheads using a thermocouple probe and readout assembly. One temperature probe mounted approximately 12 inches downstream of each wellhead will be dedicated to each extraction/monitoring well during the duration of the start-up operations. Temperature readings will be recorded to the nearest tenth of a degree using the Centigrade scale.



Vacuum drawdown will be measured at the wellhead during SVE operation using a liquid filled U-tube manometer sensitive to differential pressures as low as 0.2 centimeters of water. The vacuum drawdown port will be located at the same location of the temperature probe port at each wellhead. Soil vapor flow rate measurements will be taken during SVE operations using a Magnehelic differential flow gauge mounted to a pitot tube. A digital mass flow meter may be used as an alternative for measuring system flow. The pitot tube or mass flow meter will be located upstream of the temperature and vacuum ports such that air velocities are not affected by potential blockages in the well header. Gas flow rates will be recorded in units of standard cubic feet per minute (scfm). A field data log sheet similar to that shown in Figure B-2 will be filled out during the start-up testing and used to calculate in-situ vadose zone parameters.

It is anticipated that vacuum and flow readings will show a substantial discrepancy between SVE monitoring and extraction wells screened within the upper fine vadose zone versus those screened to intersect the lower coarse vadose zone. As such, M&E will adjust these parameters to optimize extracted air flow within each of these zones. Operation will focus on the vadose zone areas that contain the largest mass of VOC contaminants.

B.1.2. Radius of Soil Vacuum Influence (R_i)

The radius of influence to soil vapor flow of the vadose zone at the PGA site has been specified as approximately 100 feet (RI/FS, 1989; ROD, 1989). Although this is a very realistic value for wells screened within the lower coarse vadose zone, 100 feet may not be achievable in the wells screened within the upper fine vadose zone. Attempts will be made by M&E during SVE operation to optimize the upper fine radius of influence by adjusting wellhead valving, vacuum, and flow parameters. However, if the capture area within the radius of an SVE extraction well is limited to the extent that stagnation zones become evident in the subsurface, Goodyear will evaluate the possibility of constructing additional SVE extraction well(s) in order to augment SVE capture areas if needed. The need for additional wells will be determined through the use of VLEACH and mixing cell within each sub-area. The soil vapor extraction wells have been designed to be operated independently within the upper fine or lower coarse vadose zone as required. See Appendix K, Drawing M-2; Detail 6.

FIGURE B-2
SAMPLE SVE EXTRACTION/MONITORING WELL FIELD DATA SHEET

PGA SVE REMEDIATION

SOIL VAPOR EXTRACTION/MONITORING WELL OPERATION FORM

WELL DESIGNATION: _____
WELL LOCATION: _____
FLOW PIPE DIAMETER: _____

SCREEN LENGTH (FEET): _____
SCREEN INTERVAL (BGS): _____
MAXIMUM FLOW RATE: _____

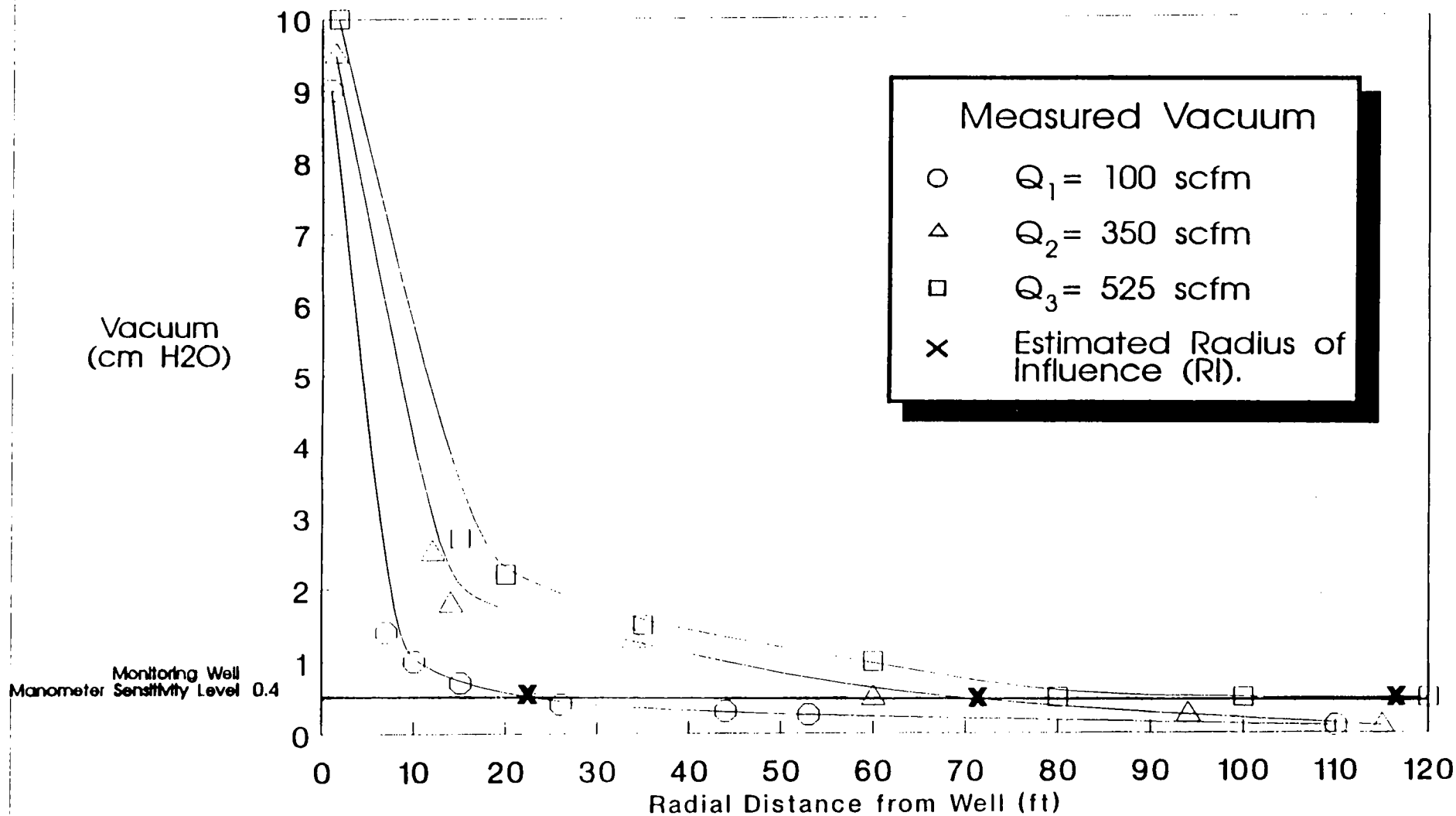
NOTE: VELOCITY TO FLOW CONVERSION (ASSUMING 4" DIAM. PIPE) = FLOW X (0.087)

[illegible]

The radius of influence (R_i) will be determined through monitoring the vacuum drawdown at the SVE extraction wellhead and at SVE monitoring wellheads during SVE operation. SVE monitoring and extraction wells will be constructed in both the upper and lower vadose zone located at selected distances radially away from the extraction well. Drawing C-1 illustrates the location of the extraction and monitoring wells, Drawing M-2, Detail G shows the vapor extraction well detail, and Drawing M-1, Detail 7 shows the vadose zone monitoring well detail. On Drawing C-1, vapor extraction wells have the designation VEW while the vadose zone monitoring wells have the designation VP. During the start-up testing, vacuum differential measurements recorded as described above will be plotted as vacuum drawdown versus distance from the SVE extraction well at several SVE system flow rates similar to the plot shown in Figure B-3. The maximum R_i value will be defined as the distance from the extraction well where the vacuum in the vadose zone measured from a monitoring well is greater than 0.4 centimeters of water (twice the minimum operational range of the manometer). Maximum R_i values will be determined in both the "upper fine" and "lower coarse" vadose zone comprising the Subunit A vadose zone. The limit of 0.4 centimeters of water vacuum was selected to minimize interference from atmospheric pressure changes during parameter measurement. A vadose zone monitoring well outside the zone of well influence will be monitored for vadose zone pressures resulting from barometric pressure changes during system start-up.

B.1.3. Air Permeability Calculations for Soils Occurring within the R_i of Extraction Well

The air permeability parameter, (k_a) will be calculated from measured field parameters collected during start-up testing. As the k_a parameter is largely a function of soil type, k_a values will be determined within both the "upper fine" and "lower coarse" vadose zone. The measured parameters will be input into a darcian analog equation relating the air permeability parameter to the pressure differential(s), measured gas flow rate(s), geometry of the extraction well, and physical properties of the extracted gas (density, viscosity, etc.). The magnitude of the air permeability will reflect native soil pore water conditions as well as soil texture. As SVE operation continues, it is anticipated that a decrease in the water content will give rise to increasing k_a values. As such, air permeability calculations will be completed following start-up testing and at the end of the six-month duration scheduled SVE operations. These values will assist in optimizing system operation.



Sample Plot of Measured Radial Pressure Distributions
from Extraction Well

FIGURE B-3

B.1.4. Radial Soil Vapor Velocity

Based on the estimated air permeability parameter, the radial soil vapor velocity will be calculated having knowledge of differential pressures using a modified darcian equation. Radial soil vapor velocity determination will allow M&E to evaluate radial sweeping efficiencies of the SVE system as a function of both soil type and applied differential pressure. The radial soil vapor velocity, being largely controlled by the applied vacuum across a well of given diameter, will be optimized through manipulation of the applied vacuum across SVE extraction wells during SVE operation.

The radial soil vapor velocity, once determined, will be used to determine the number of pore volumes of vadose zone vapor that will be required to achieve a desired remediation level that satisfied the conditions of Appendix B of the 1990 Consent Decree. Section B.1.10 describes sub-area remediation time in greater detail.

B.1.5 Soil Vapor Flow Field Determination

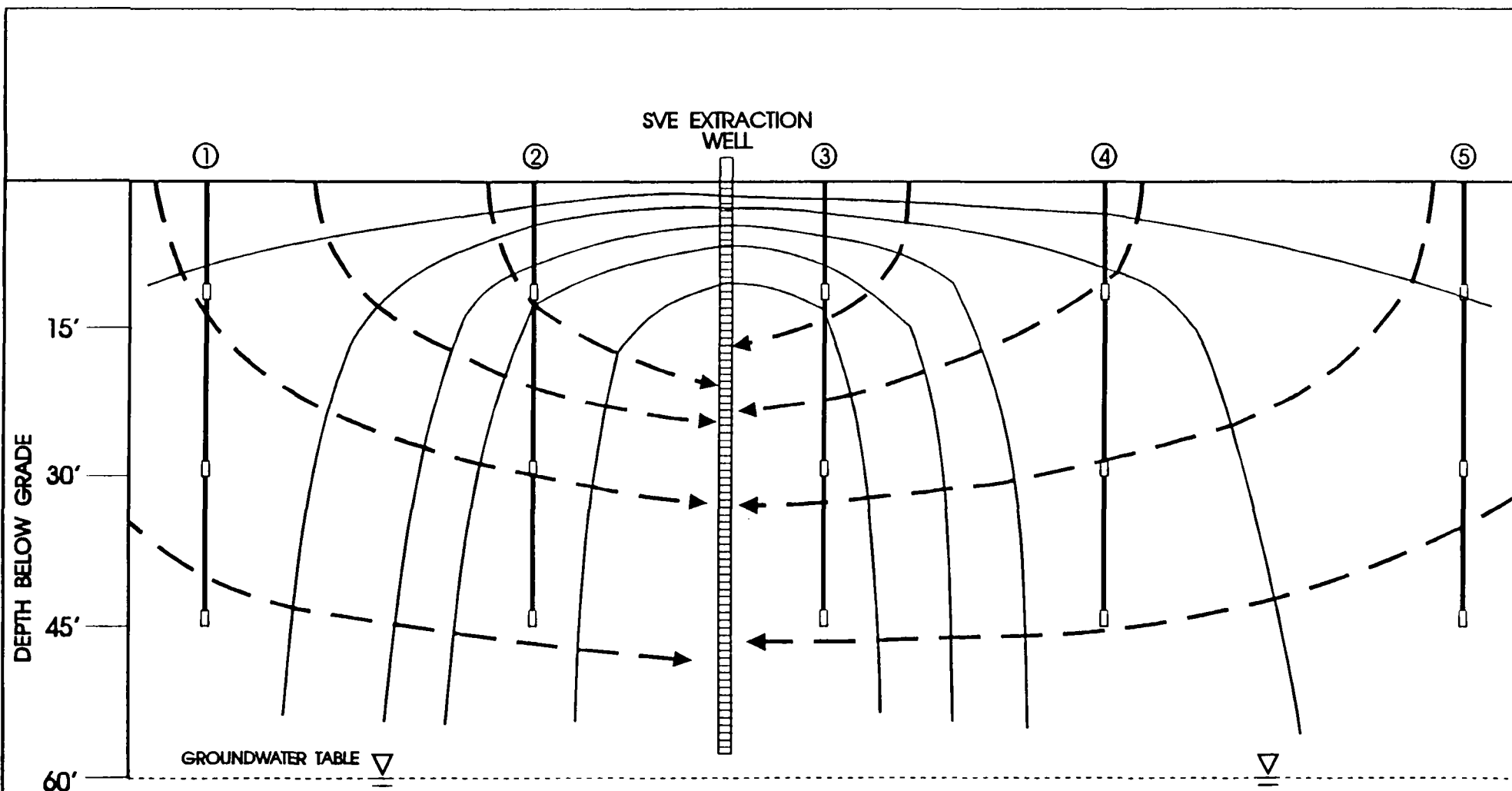
Based on the vacuum drawdown records established during start-up operations, soil vapor flow fields will be constructed to model the nature of subsurface advective soil vapor flow. This will prove effective when evaluating whether vapor stagnation points may exist in the subsurface during operation and for optimization of subsurface flow conditions. Construction of flow fields will also prove valuable when evaluating the conductivity of different soil types in the vadose zone to soil vapor flow. A modified groundwater flow model adapted for vadose zone advective flow may be used for optimizing SVE operation. Figure B-4 illustrates the format in which M&E will present and evaluate dynamic flow field conditions. In addition to the cross-section diagrams, M&E will prepare contoured plan diagrams for multiple well influence determinations. The findings generated from the flow field determination analysis will be used to fine tune the SVE system performance.

B.1.6 SVE Monitoring and Extraction Well Soil Vapor Sampling/Analysis

During and following start-up operations, soil vapor samples will be collected from the SVE extraction and monitoring wells for analysis in the field or at a certified analytical laboratory. Field analytical samples will be collected from SVE monitoring and extraction well headers during SVE operation in 3-liter capacity tedlar bags using a vacuum pump connected to a vacuum sampling box and will be screened in the field with a GC. Because negative pressures will be present in operating SVE well headers, effective soil vapor sample collection will require initially setting the vacuum sampling pump at a negative pressure greater than that measured in the well header. Wellhead vacuums and vacuum sampling pump settings will be recorded during each sampling event. Sampling will commence after steady-state conditions are achieved at a given flow rate.

A analysis of collected soil vapor samples will be routinely performed in the field using hand-held PID instruments. During rebound monitoring (Section B.2-11), soil vapor samples will be analyzed in the field using a gas chromatograph (GC). Based on the results of the field GC analysis during rebound monitoring (e.g. if estimated ARM (1990 Consent Decree, Appendix B) levels have been met), laboratory sampling will be initiated.

Laboratory samples will be collected in precleaned, passivated SUMMA canisters and forwarded to a certified laboratory for chemical analysis. SUMMA canisters have a number of advantages over other types of laboratory sampling containers. SUMMA canisters are manufactured with an electropolished interior and are easily cleaned in the laboratory, and, stand little chance of becoming internally contaminated. Additionally, SUMMA canisters as they have been used at the PGA site collect three liter capacity samples. Because of the large sample volume, method detection limits for TO-14 analyses are low, and will yield accurate and quantifiable concentrations in soil vapor samples both at and below ARM concentration levels (see Appendix H). It is for these reasons that M&E proposes to collect all subsequent SVE Extraction and monitoring well laboratory soil vapor samples in 3-liter capacity SUMMA canisters, as opposed to switching between SUMMA canisters during early SVE field operations, and then to carbon adsorbent sampling tubes as SVE remediation or vadose zone monitoring progresses.



EXPLANATION

① SVE MONITORING WELL

SCREENED DEPTH

SOIL VACUUM CONTOUR

SOIL GAS FLOW DIRECTION

CONCEPTUAL CROSS-SECTIONAL
IN SITU SOIL VACUUM CONTOUR
MAP SHOWING SUBSURFACE
SOIL GAS FLOW FIELD

M&E Metcalf & Eddy

Drawn by:
J. Weldmann

Checked by:
S. Zachary

Job
Number:
006791

Date:
September 1992
Figure Number:
B-4

Based on VLEACH and Mixing Cell modeling for the polygon to undergo SVE remedy, a threshold operational ARM concentration will be determined subsequent to the Phase I/II investigation vertical soil vapor distribution (see Section B.2.12). The on-going SVE field operations will target the maximum hydrocarbon concentration level of at least the estimated threshold ARM concentration for continued remediation. If the threshold concentration is less than 1 ppmV, a field gas chromatograph will be used for routine and field rebound well vapor monitoring (see Appendix H).

B.1.7. Soil Vapor Contaminant Composition and Maximum Concentration

Collected SVE extraction and monitoring well soil vapor samples will be analyzed for maximum hydrocarbon concentration to determine the type and concentration of contaminant(s) present in the vapor. For maximum concentration field analyses, total ionizable hydrocarbons will be measured using a Portable Gas Analyzer (PID), and/or the field GC. The analyst will be instructed to quantify and integrate concentrations of the four VOC target compounds which include TCE, PCE, 1,1-DCE, and 1,1,1-TCA. The field GC will be used for speciation of the four targeted compounds TCE, PCE, 1,1-DCE, and 1,1,1-TCA. Certified laboratory maximum concentration analyses will be performed on SUMMA canister samples collected from well headers using EPA Method TO-14 as needed. Fixed gas analyses (CO_2 , O_2 , CH_4) will be screened in the field using a portable infra-red gas analyzer and used to evaluate well sealing efficiencies and to evaluate SVE influence within the "upper fine" and "lower coarse" vadose zone.

B.1.8. Critical Soil Vapor Flow/Vacuum Rate Determination

The goal of operating the SVE extraction well(s) is to maximize volatile vapor extraction through controlling the parameters, where possible, that affect VOC transport and removal. During start-up operations, the SVE system will be operated at a range of system flow and differential vacuum conditions. Following receipt of soil vapor chemical analyses, and completion of air permeability, radial velocity, and flow field analyses, M&E will evaluate and determine the optimal system parameters that yield the maximum contaminant concentrations from the vadose zone soils existing in the first sub-area of Polygon 79. Over time, as it is expected that subsurface conditions may

change, therefore, M&E will continue to collect pertinent data as it pertains to determining the most efficient on-going remedial operating parameters. Once the parameters have been developed, all of the polygon wells will be operated to maximize operational efficiency.

B.1.9 Extraction Well Efficiency

The SVE operable unit wells have been designed to independently treat the upper fine and lower coarse vadose soils. Appendix K, Drawing M-2, Detail G illustrates the soil vapor extraction well construction. Initially, both the upper and lower screened wells will be operated using the SVE system. As remedial progress continues, if it is determined that either the upper fine or lower coarse well is not producing VOC vapors to cost effectively remediate the soils, the non-producing well will be turned off and remediation will focus on the producing counterpart well(s).

Determination of the efficiency of the individual wells will be evaluated through the collection and evaluation of field vadose zone fixed gas concentrations. The fixed gas concentrations in the vadose zone, particularly oxygen, are less than 17% by volume. If the oxygen concentrations in the SVE extracted vapor is significantly higher than 17% or the concentration of the nearest soil vapor monitoring well, vapor short circuiting is likely occurring from the ground surface.

All wells will be operated in a manner to minimize the effects of ambient air short-circuiting and maximize well efficiency.

B.1.10 Sub-Area Remediation Duration Modeling

In an effort to predict the SVE extraction well start-up and shut-down cycles, M&E will develop simple sub-area-specific predictive models for VOC concentration decay.

Field and laboratory VOC data collected during both operation and shut-down will be plotted on a linear basis to determine any trend in the data. Based on the data trend, a regression equation will be fitted to the data for production purposes. Once the regression model has been determined for each sub-area, the ARM concentration for the sub-area will be input and the total operational

duration to achieve this concentration will be predicted. Figure B-5 illustrates a typical sub-area predictive model utilizing an exponential regression equation.

As additional data becomes available, it will be added to the model and the predictive model equation will be modified to reflect the real-time data.

Once the model has been updated, a new predicted remediation time to achieve the ARM concentration will be generated.

B.2 ON-GOING EXTRACTION WELL O&M PLAN

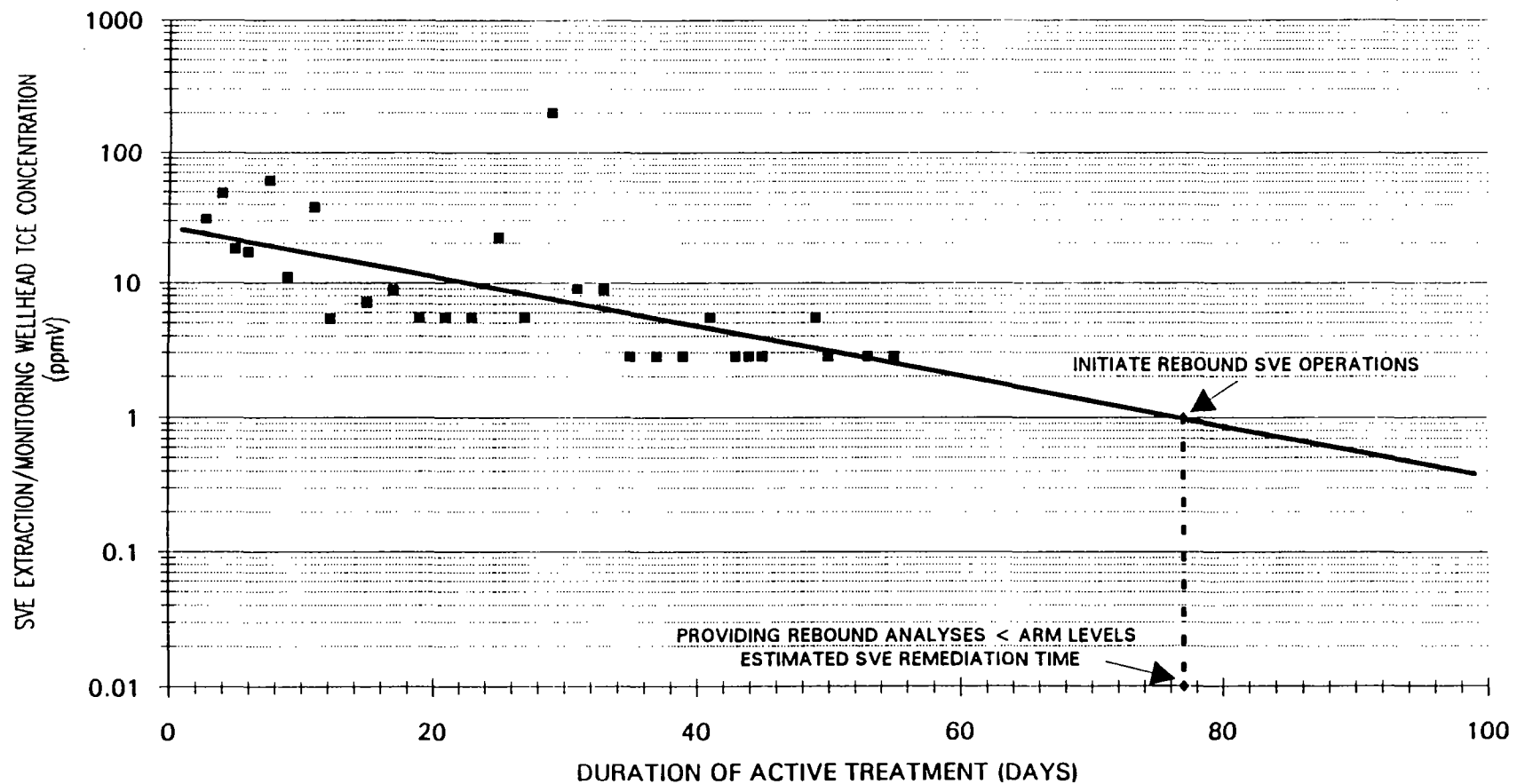
As described in detail in Section B-1 the following data and/or parameters will be recorded/determined during system Start-Up, and re-evaluated at the completion of the six-month SVE operation at the first Polygon 79 sub-area extraction well. The techniques and methodologies employed to measure/determine the eleven (11) parameters identified during start-up operation will be identical to those employed during on-going operations with the inclusion of SVE extraction well rebound monitoring and SVE sub-area Allowable Residual Mass (ARM) determination for routine monitoring and the maintenance elements listed below:

On-going SVE extraction/monitoring well monitoring/data parameter determination

1. Extraction/monitoring wellhead temperature, vacuum, and flow rate
2. Radius of soil vacuum influence
3. Air permeability calculations for soils occurring within the radius of influence
4. Radial soil vapor velocity
5. Soil vapor flow field determination
6. SVE monitoring and extraction well soil vapor sampling
7. Soil vapor contaminant composition and maximum concentration
8. Critical flow/vacuum rate determination
9. Extraction well efficiency
10. Sub-area remediation duration modeling

FIGURE B-5

ESTIMATED SVE REMEDIATION DURATION FOR A HYPOTHETICAL SVE EXTRACTION WELL



NOTE: ARM CONCENTRATION > 1 ppmV

11. SVE extraction well rebound monitoring
12. SVE sub-area ARM assessment

On-going SVE Well Maintenance will include:

1. Field monitoring instrument calibration and cleaning
2. Wellhead inspection and valve control/adjustment

Measurement and/or calculations of the ten elements (B-2.1 - B-2.10) will be carried out over the course of Subunit SVE Remedy as described in Section B-1. Monitoring items B-2.11 and 12 are discussed in greater detail below.

B.3 SVE EXTRACTION WELL REBOUND MONITORING

During on-going SVE extraction well operation, it is anticipated that subsurface soil vapor concentrations will decrease as remediation progresses. At these instances, it is scientifically and economically prudent to temporarily discontinue SVE operation and permit SVE operational subsurface conditions to re-equilibrate to ambient vadose zone conditions. Intermittent SVE operation is herein termed "pulsing" and is in accordance with Appendix B of the 1990 Consent Decree. During the periods when the system is shut down, monitoring is essential to assess the potential of VOC soil vapors to recollect and "rebound". As SVE remediation progresses within the sub-area extraction wells, the targeted SVE soils may reach a situation where further removal of volatile vapors becomes a "diffusion-limited" process (ie. regardless of the vacuum applied to an extraction well, in the short term, the net removal of volatile vapors remains essentially the same). This diffusion limited condition is expected to exist within the upper fine soil to a greater extent than in the lower coarse soils, given the diminished ability of the fine soils to readily transmit advectively driven vapor flow. In this event, the productive SVE extraction well will remain online, while the non-productive well valve will be temporarily shut off.

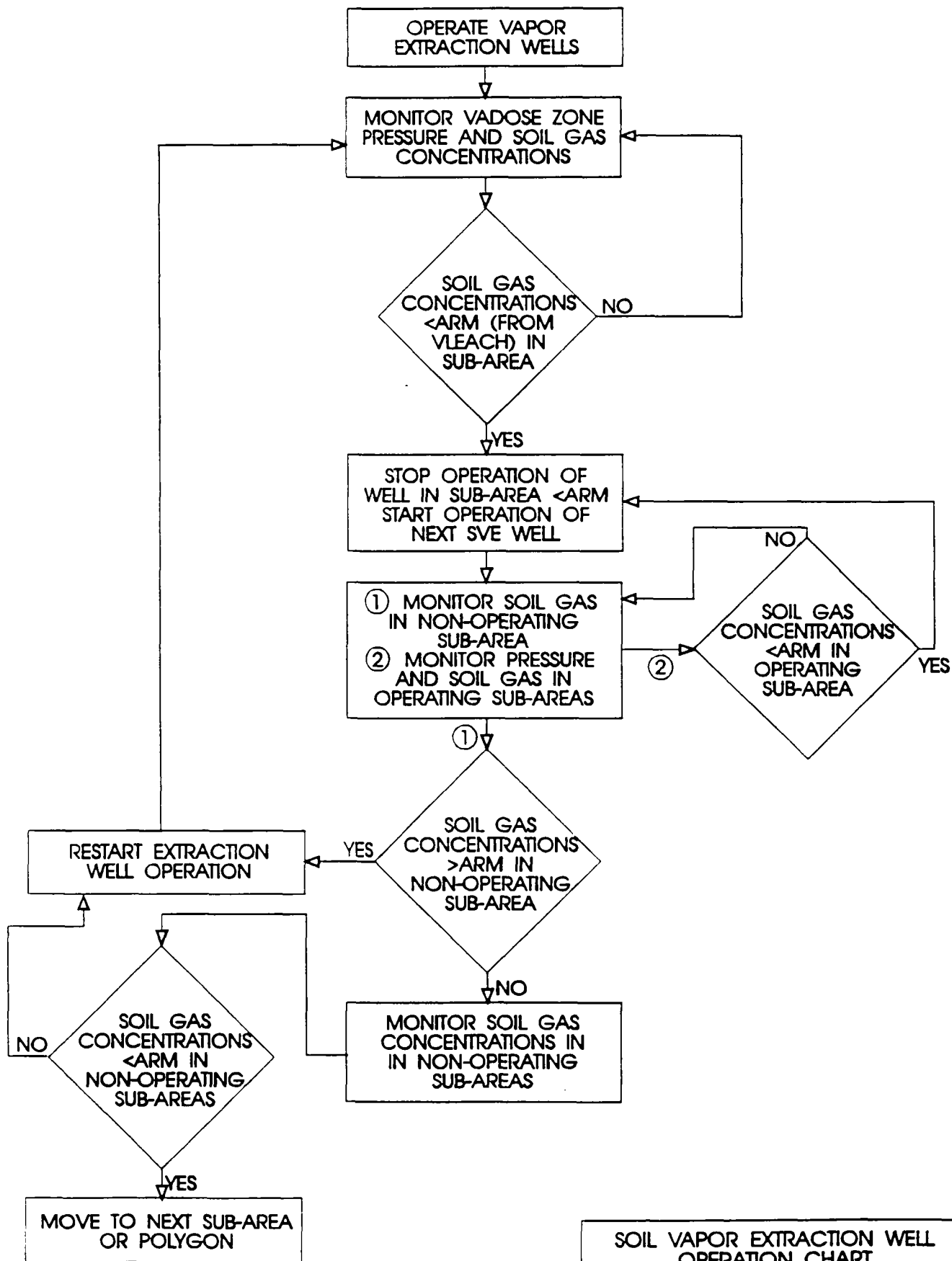
Routine monitoring of SVE monitoring wells will continue so long as VOC concentrations measured from the operating SVE extraction well remain above the soil vapor concentration determined by

VLEACH to exceed the sub-area specific ARM concentration. In the event where the SVE extraction wells screened across both the shallow and deep soils fail to yield VOC concentrations of at least the ARM concentration as measured by the field instrumentation (PID), the SVE system and extraction well valves will be shut off. The incidence of subsequent rebound monitoring will be initiated after it is determined through field monitoring that the first sub-area SVE extraction well vapors fall below the ARM concentration (see Section B.2.12).

During the period that the SVE system is off, the dynamic relationship between the sorbed, dissolved, and gaseous phases are permitted to re-equilibrate, and volatile gases are permitted to naturally diffuse into and fill previously evacuated pores within the soil matrix. Subsequent SVE operation, if required, will readily remove the collected vapors and the process is repeated until a targeted cleanup level is achieved and sustained as determined by VLEACH and Mixing Cell in accordance with Appendix B of the 1990 Consent Decree.

The proposed O&M schedule, Figure B-1, provides for two rebound monitoring events for Polygon 79 during the first six-month SVE extraction well operation period. These proposed scheduled events are tentative, however, as SVE operations ensue, system performance parameters, as they become available, will provide M&E with the necessary data to assign and confirm actual rebound and related monitoring events. Prior to discontinuing SVE operations for rebound assessment, a comprehensive SVE operations monitoring event is scheduled (see Figure B-1, On-going SVE monitoring). M&E proposes to allow a time period of 7-10 days to elapse following SVE shut-down to allow sufficient time for subsurface conditions to equilibrate. Immediately following this period, M&E will collect laboratory soil vapor samples from the SVE monitoring wells located within the capture area of the first SVE extraction well for analysis.

The analytical soil vapor data collected from the SVE monitoring wells will be treated in a fashion similar to that discussed in section 2.2.1. Following input into the VLEACH and Mixing Cell models, a determination will be made as to whether ARM concentration levels have been met within the first SVE extraction well (see Figure B-6 flow diagram). This determination will hinge upon the potential of the existing soil vapor concentrations to result in Subunit A groundwater concentrations above 5.0 $\mu\text{g/L}$ as determined by VLEACH and Mixing Cell screening.



SOIL VAPOR EXTRACTION WELL OPERATION CHART



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Date:
September 1992

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Figure Number:
B-6

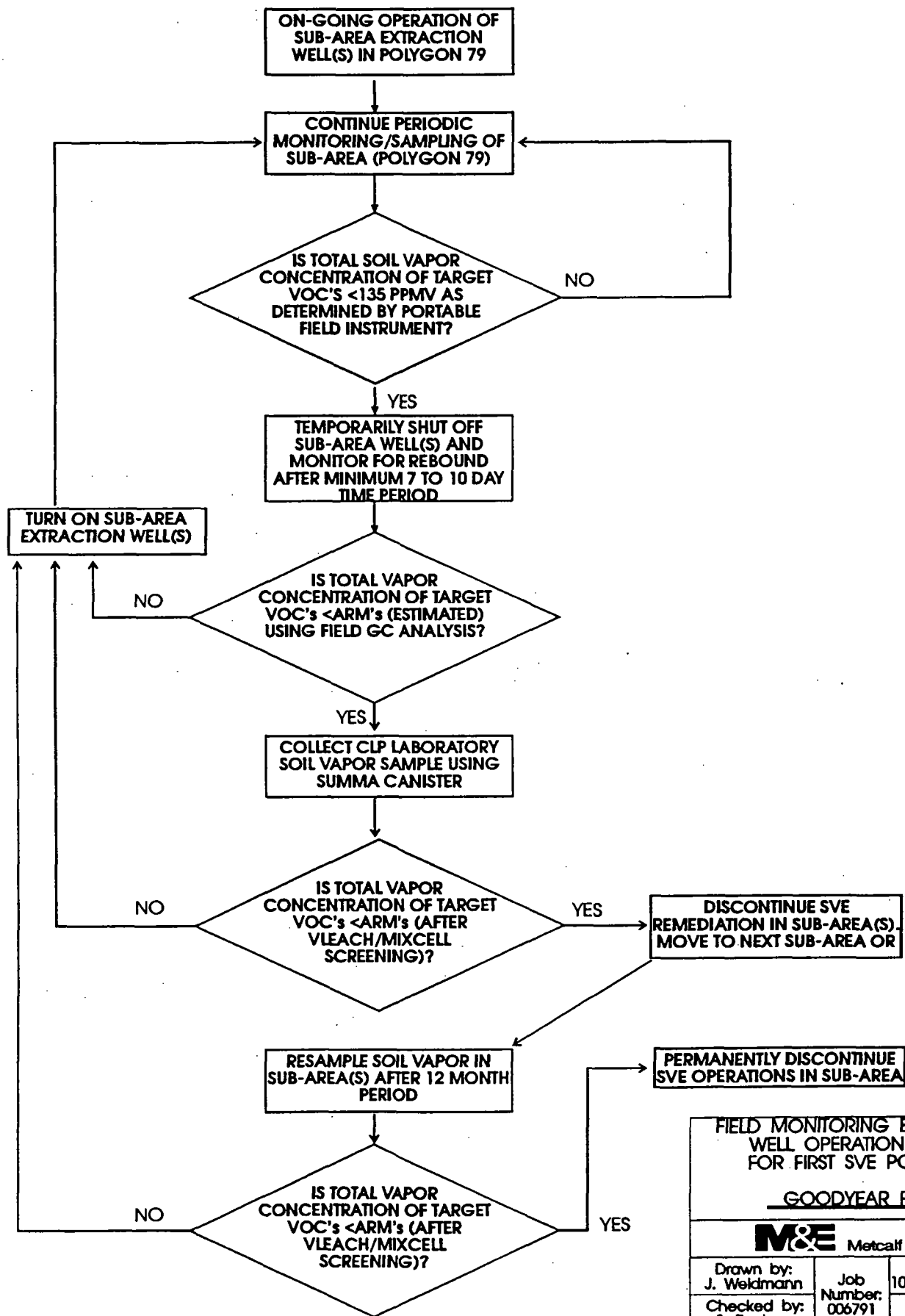
As shown in Figure B-7, from Appendix B of the 1990 Consent Decree, an individual SVE sub-area extraction well will continue to operate as long as groundwater VOC concentrations (as TCE) > ARM's and/or SVE monitoring well soil vapor samples collected during rebound monitoring result in modelled VOC levels that exceed ARM criteria. If either the groundwater VOC ARAR's or soil vapor ARM levels fall below acceptance criteria, the SVE system will be shut down and be monitored for rebound. If, following rebound monitoring, either groundwater VOC > ARAR's, or soil vapor > ARM levels, SVE operation will continue. Alternately, in the event that rebound monitoring groundwater VOC < ARAR's and soil vapor samples result in modelled VOC concentrations below ARM levels, the operating SVE extraction well will be shut off. This process will continue until all of the sub-areas within the polygon comply with Appendix B of the Consent Decree. (See Figure B-7). In order for a sub-area to be permanently discontinued from further SVE remedy, soil vapor concentrations must remain below the ARM for a period of twelve (12) consecutive months as outlined on Page 18 of the 1990 Consent Decree. If this condition is upheld for any particular sub-area(s), SVE remediation will be permanently discontinued for that sub-area(s).

B.3.1 ARM Estimation Criteria for Rebound Monitoring

The sub-area specific ARM concentration threshold with which to base the decision as to whether or not to shut off a well and initiate rebound monitoring will be based on the VLEACH and Mixing Cell models. For monitoring well VP-79 in Polygon 79, ARM estimation was carried out as follows (see Figure B-7).

- Assume that the vadose zone is uniform and is characterized by a single average total VOC (as TCE) soil vapor concentration ($\mu\text{g/L}$).
- Select a single total soil vapor concentration, convert this value to total soil concentration using the following relationship:

$$C_t = K_{gt} \times C_g$$



FIELD MONITORING EXTRACTION
WELL OPERATION CHART
FOR FIRST SVE POLYGON

GOODYEAR PGA

M&E Metcalf & Eddy

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Date:
10 November 1992
Figure Number:
B-7

Where:

C_t = total soil concentration ($\mu\text{g/Kg}$)

C_g = total soil vapor concentration ($\mu\text{g/L}$)

K_{gt} = total soil vapor to total soil concentration conversion factor (L/Kg)

The value of K_{gt} has been calculated from site-specific soil physical data, and physicochemical constants. The value of K_{gt} is to be taken as 0.599 L/Kg .

- Input the converted total soil concentration value with the appropriate sub-area specific values into the VLEACH model. The total soil concentration value will be entered adjacent to the ten (10), six-foot thick cells comprising the vadose zone.
- Run the VLEACH model at one-year mass flux output statements, 10-year printout summaries, over a 30-year duration (or until a peak mass flux is demonstrated).
- Run the Mixing Cell model using the VLEACH output with groundwater impact printouts on a one-year basis over the duration that the VLEACH model was run (e.g., typically a 30-year duration).
- Reiterate this process using a range of converted total soil vapor concentration values. Repeat this process until an approximate threshold total soil vapor concentration and associated ARM value is established that, when exceeded, gives rise to contributing to Subunit A groundwater TCE concentrations in excess of $5 \mu\text{g/L}$.
- Convert this threshold total soil vapor concentration ($\mu\text{g/L}$) into units of parts per million by volume (ppmV). Divide this value by two to allow for a marginal safety factor associated with rebound effects.
- Use this adjusted sub-area specific total soil vapor concentration in ppmV as the field monitoring criteria for ARM estimation.

Using this approach allows for a technical basis for sub-area operation and shut-down that is tied to the 1992 Consent Decree (Appendix B). Since each sub-area may contain vadose zone-specific parameters that effect vadose zone-specific parameters that effect contaminant transport and removal, each sub-area will have an ARM threshold concentration developed from sub-area specific soil vapor data. Development of these parameters for each sub-area will allow for SVE operation to be suspended in one or more areas during polygon remediation.